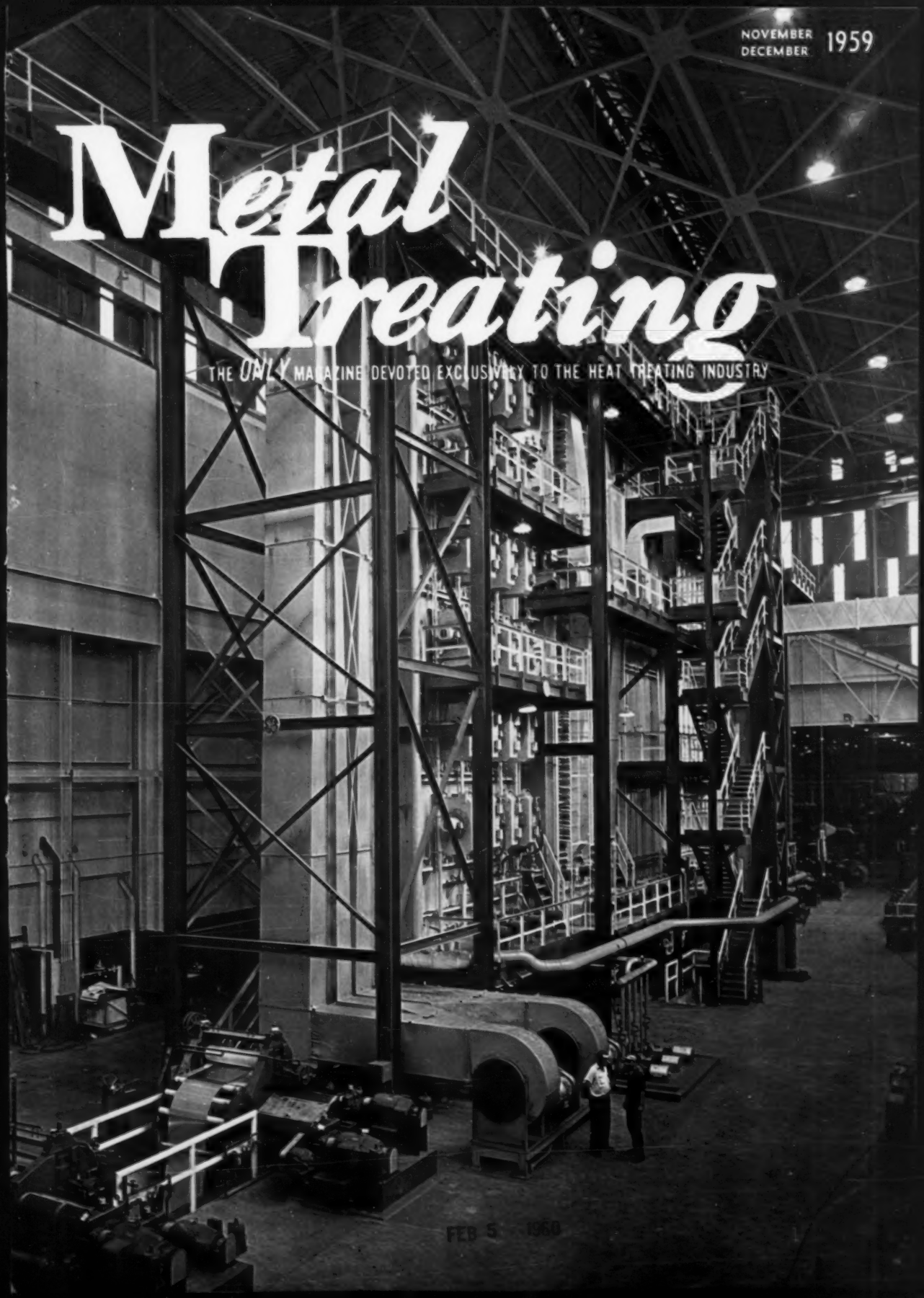
NOVEMBER
DECEMBER 1959

Metal Treating

THE ONLY MAGAZINE DEVOTED EXCLUSIVELY TO THE HEAT TREATING INDUSTRY



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Vol. X
NOVEMBER-DECEMBER
No. 6

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The presentation of editorial material in "Metal Treating" should not be interpreted as either an endorsement or recommendation by the Metal Treating Institute of the statements set forth.

Published bimonthly by the Metal Treating Institute, 271 North Avenue, New Rochelle, N. Y. Phone: NE 6-4658.

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Accepted as Controlled Circulation publication at New York, N. Y.

The Cover

New General Electric tower-type, jet cooled continuous annealing furnace at the Wheeling Steel Corporation plant, Yorkville, Ohio. Jet coolers, major break-through in furnace design, can be seen in banks of four along the furnace side. For more details see page 26.

Photo courtesy General Electric Company

BRAZING

STAINLESS HONEYCOMB

By **THOMAS A. DICKINSON,**

West Coast Reporter

FURNACE, electric blanket, die quench, and salt bath brazing methods recently developed by North American Aviation, Inc., Los Angeles, are solving many of the problems associated with the production of stainless steel "sandwich" components for B-70 and F-108 aircraft.

In 1957, when North American initially received contracts for the latter airplanes, the sand seal double retort was the airframe industry's standard brazing facility (see Fig. 1). Because massive graphite was used in the inner retort as a reference plane to maintain part contours, this necessitated a continuous argon purge because graphite was a possible source of air or moisture during each brazing cycle. In addition, long floor-to-floor brazing time was essential due to tooling weights and configurations; and there were many practical limitations on the dimensions of parts that could be brazed.

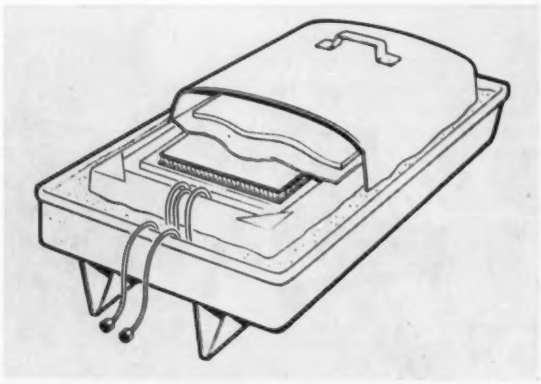


Fig. 1—Sand seal double retort brazing facility

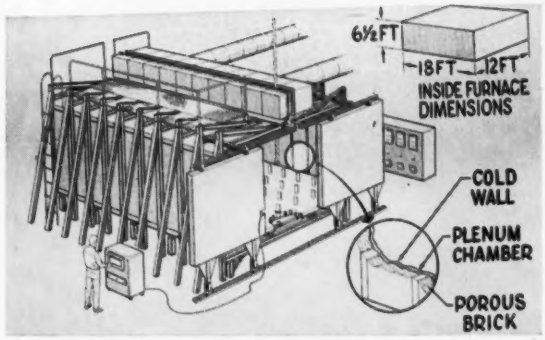


Fig. 2—Luminous wall brazing furnace employing a new principle in burning gas

The material commonly used in making sandwich details was 17-7PH steel with an ultimate tensile strength of 180,000 psi, and brazing was usually done with a silver-manganese alloy.

In the B-70 and F-108, North American engineers

decided to use PH15-7Mo as a basic sandwich material in order to obtain ultimate tensile strengths of 225,000 psi. Since it was found that silver-manganese filler was susceptible to crevice corrosion, they further came to the conclusion that it would be desirable to use a sterling silver-lithium brazing alloy.

Because it was necessary to convert these relatively new materials into reliable parts with unprecedented dimensions and configurations, it then became obvious that new brazing methods were needed; and the following possibilities were selected for immediate refinement:

- Furnace brazing—for the production of very large parts;
- Electric blanket brazing—for the manufacture of components with complex curvatures;
- Die quench brazing—for the fabrication of parts with flat surfaces or slight curvatures; and
- Salt bath brazing—for the production of special components with very heavy sections.

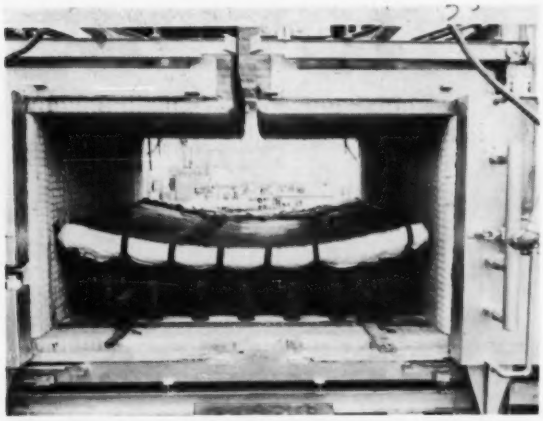


Fig 2a—A 10' x 14' curved stainless steel panel with honeycomb core in a luminous wall brazing furnace

Luminous wall furnace brazing is one of the more advanced techniques that the company has consequently developed (Fig. 2). It involves the use of a furnace which employs a new principle in burning gas.

The inner linings of a luminous wall furnace are 9″-thick panels of porous refractory brick, behind which is a deep 2″-deep plenum chamber and a steel outer wall in each instance.

Gas and air are premixed outside of the furnace and then manifolded into the plenum chambers at a very low pressure (5″ H_2O) so that the premix will seep through brick pores and be ignited after penetrating the inner wall. Thus, a complete wall of flame is rapidly generated and the brick lining becomes incandescent, producing a radiating surface that requires no convection or conduction to transfer heat.

Because there is almost no heat storage in the brick,

Fig. 2b—This 10' wide x 14' long panel shown here in North American's Los Angeles plant is believed to be the largest stainless steel component that has yet been made by brazing sheet and honeycomb core materials

the rapid cool-down essential to quality brazing can be achieved simply by halting the flow of gases at the premixer without causing damage due to thermal shock. In fact, an auxiliary system of blowers may be used to pass large volumes of air through a series of controllable ports along the furnace's walls at the floor line to accelerate cooling.

Radiating surfaces in a luminous wall furnace can be divided into as many control zones as may be desired for rapid heat-up rates and forced, controllable cooling. Moreover, an exhaust slot in the roof can greatly facilitate furnace loading by permitting the use of a hoisting or lifting device.

Double differential retorts used by North American

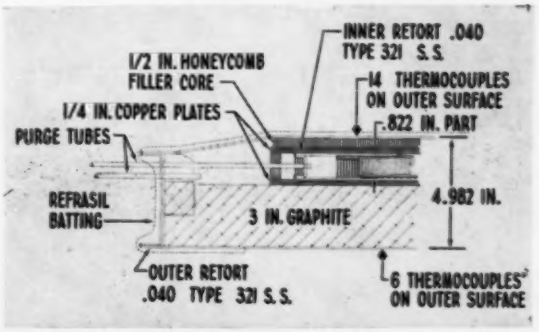


Fig. 3—Double differential retort layup for luminous wall furnace brazing of a 10' x 14' flat panel has temperature gradient equalizers made from copper

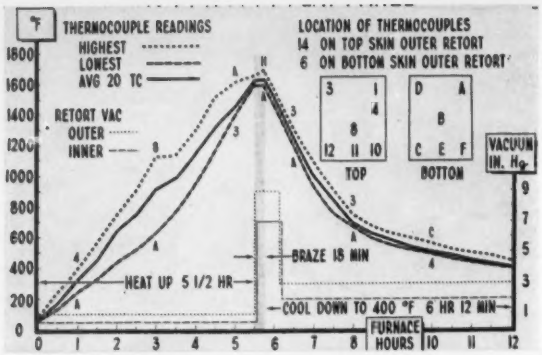


Fig. 4—Actual time-temperature and vacuum readings made during a 12-hour brazing cycle on a 10' x 14' flat panel in a luminous wall furnace

for luminous wall furnace brazing have temperature gradient equalizers made from copper (Fig. 3). This makes it possible to control part temperatures within very narrow limits, so as to eliminate the likelihood of skin wrinkling.

Copper is placed as close as possible to braze interfaces, and it evens out heat source temperature differentials. It also equalizes differential heat transfer from thick and thin sections during cool-down, thus making it practical to braze very large honeycomb structures —including those with heavy inserts.

Copper equalizers are made from ¼"-thick materials where large panels must be brazed; ⅛"-thick materials where small panels will be produced. Phosphorized, deoxidized, or oxygen-free grades of materials are employed in all cases to avoid copper blistering.

Instead of conventional thermocouples, North American's furnace retorts in some instances have calibrated iron-constantin covered wires whose ends are directly spotwelded to outer-retort sheets.

A honeycomb filler core, which is ½" thick, is usually placed over the top cover sheet on each retort and covered with Refrasil batting (a leeched silica fabric) in order to obtain the same heat transfer resistance as that of a 3"-thick graphite tool which is below the workpiece. However, where identical top-to-bottom heat transfer paths are desirable, a graphite slab with the thickness of the base tool can be used instead of the filler core and part of the Refrasil batting.

Layers of ¼"-thick Refrasil batting are always used around retort edges to prevent leaks due to thermal shock.

In brazing some of the largest panels yet made with 15-7Mo sheet and honeycomb in luminous wall furnace retorts, North American has obtained parts with yield strengths up to 227,000 psi where only 200,000 psi was required; ultimate strengths up to

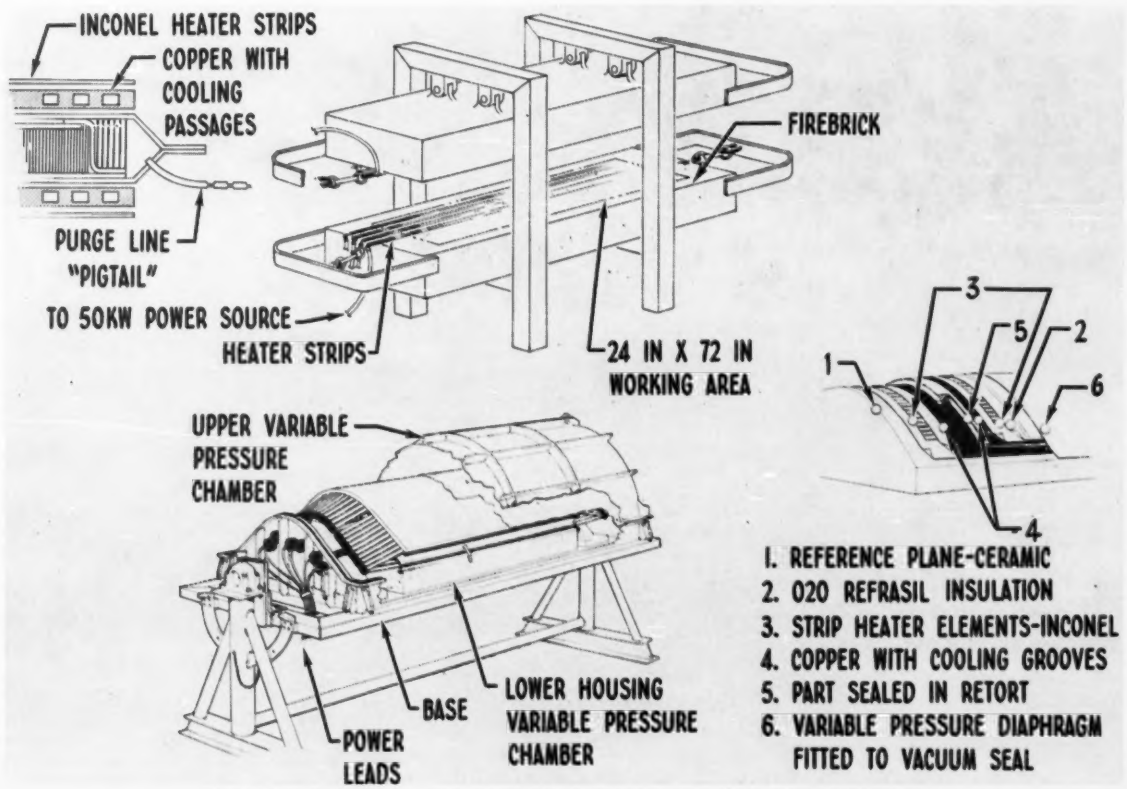


Fig. 5—The single retort setup for electric blanket brazing at North American Aviation, Inc.

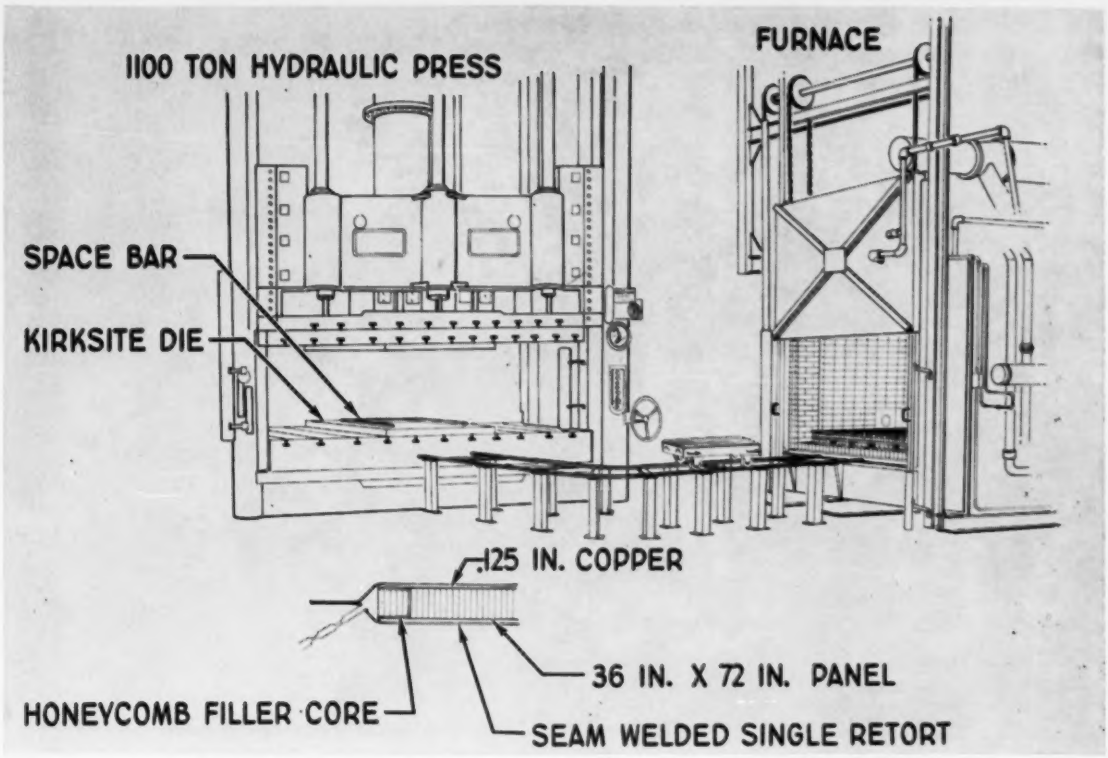


Fig. 6—Horizontal furnace setup for die quench brazing in order to avoid alloy-flow prob'ems

242,000 psi where only 225,000 psi was required; and elongation of 6½ per cent where only 4 per cent was required. Further, there were no defects such as waves or wrinkles in facing sheets or close-outs.

Fig. 4 shows actual readings that were made during a 12-hour braze cycle for one 10′ x 14′ flat panel in a luminous wall furnace. Here, the even cool-down to 1000° F is of particular interest because it is the most important part of the brazing cycle.

The considerable temperature spread during heat-up (500° F after 3 hours) was not harmful because of the use of a temperature gradient equalizer and minimum vacuum pressures which allowed components to move freely. However, the spread could have been reduced by allowing the furnace to stabilize at various temperature settings during heat-up if it hadn't been most desirable to minimize the length of the brazing cycle.

In electric blanket brazing, North American uses a single retort setup (Fig. 5) with a copper temperature-gradient equalizer which has grooves for the circulation of air when fast cooling becomes necessary. The retort is placed between two platens and heating is rapidly done by passing electricity through Inconel strips which are insulated with Refrasil cloth. Precision temperatures, thus obtainable, make the procedure especially suitable for the brazing of contoured panels.

Where severely contoured parts must be assembled with electric blanket equipment, a sheet metal diaphragm is positioned between the retort and an upper pressure chamber so that rubber seals can be used to make both upper and lower chambers airtight. This permits the use of either positive or negative pressures during a brazing cycle. Trunnion mountings have made it possible to use electric blanket setups to study alloy rundown problems.

Electric blanket brazing has the advantage of being relatively fast and efficient, but it also has the disadvantage of necessitating the use of relatively expensive tooling. However, recent tests have indicated that tools suitable for this type of work can be made from Glasrock Foam and Masrock, two unusual refractories produced by Glasrock Corporation in Atlanta, Georgia.

For die quench brazing, North American uses a horizontal furnace setup (Fig. 6) in order to avoid alloy-flow problems that can occur when sandwich structures are heated in vertical positions. In most other respects, the furnace is conventional and has a large heat storage capacity in its walls.

The furnace is stabilized at brazing temperature while empty, and components to be brazed are laid up in a single retort. A charging cart subsequently

(Continued on page 40)

MISSILE METALLURGY

Some Facts on the Selection of Materials and the Heat Treatment of Rocket and Missile Bodies

By **HORACE C. KNERR**
Consulting Metallurgical Engineer
President, METLAB CO., Philadelphia

Author's Note: It is hoped that this article finds some circulation among those concerned with the design and manufacture of rocket bodies whose metallurgical knowledge may be incidental. It has therefore been attempted to discuss fundamental heat treating problems in practical terms, including certain matters that are doubtless well known to metallurgically-trained readers.

THE DEVELOPMENT of rocket and missile[1] hardware has notably followed the evolution of aircraft construction. Performance of rockets, as of aircraft, depends upon a minimum of structural weight, with a maximum of accuracy in form. Each pound saved in the structure permits carrying more fuel, increasing the range, speed, and payload, or a desired combination of these. Payload in rockets is represented by instruments, warheads or passengers. Rapid acceleration, —take-off—is perhaps even more essential to rockets than aircraft, and demands minimum inertial weight.

Engineering conditions are such, in both rockets and aircraft, that the benefits of weight saving are cumulative. An extra pound of dead load requires the addition of many pounds of fuel to maintain equal performance ("to carry a fountain pen to the moon needs 20 pounds of fuel"). Additional fuel in turn requires more structural weight, and so on, in a rising spiral.

Conversely, even a small saving in dead weight can enormously increase payload. In aircraft this is realized in every flight. In a rocket it applies only once, but that improvement may be crucial. (A satellite weighing 90 lbs. may require a 60 ton gross weight of hardware and fuel to place it in orbit; — a ratio of 1333 to 1. Would saving 90 lbs. or .075% in the weight of the structure permit doubling the payload?)

Accuracy of form is extremely important in rockets as in aircraft. The slightest deviation, say, in the contour or angle of wings, will detract tremendously from the flight efficiency of an airplane. Similarly, if the body of a rocket is out-of-round, bowed or otherwise unbalanced, speed, range and target accuracy suffer to an exaggerated degree. (The writer once asked Dr. Schilling, technical associate of Dr. Wernher von Braun at Redstone, how serious a deviation of ⅛" in the roundness of a certain rocket body would be. After a few swift calculations he replied, "That would increase the load on the steering control mechanism by 25%.")

Strength-Weight Factor

The struggle to reduce dead weight in rockets, as in aircraft, has resulted in the search for ever lighter materials of construction. Long ago[2], it was recognized that "lightness" in a structural material is *not* measured by its weight per cubic inch. So-called light metals such as aluminum and magnesium may be, and usually are, "heavier" than steel. This, obviously, is because the weight of a structural member depends on how much material is required to support the designed load or withstand the working stress. If the figure used in design is yield strength, then an evaluation between two materials can be made by comparing the figures ob-

[1] For simplicity, referred to as rockets herein, and includes boosters, jatos, etc.

[2] "Materials Selection on Strength-Weight Factors"—H. C. Knerr, *Automotive Industries*, April 19, 1923.

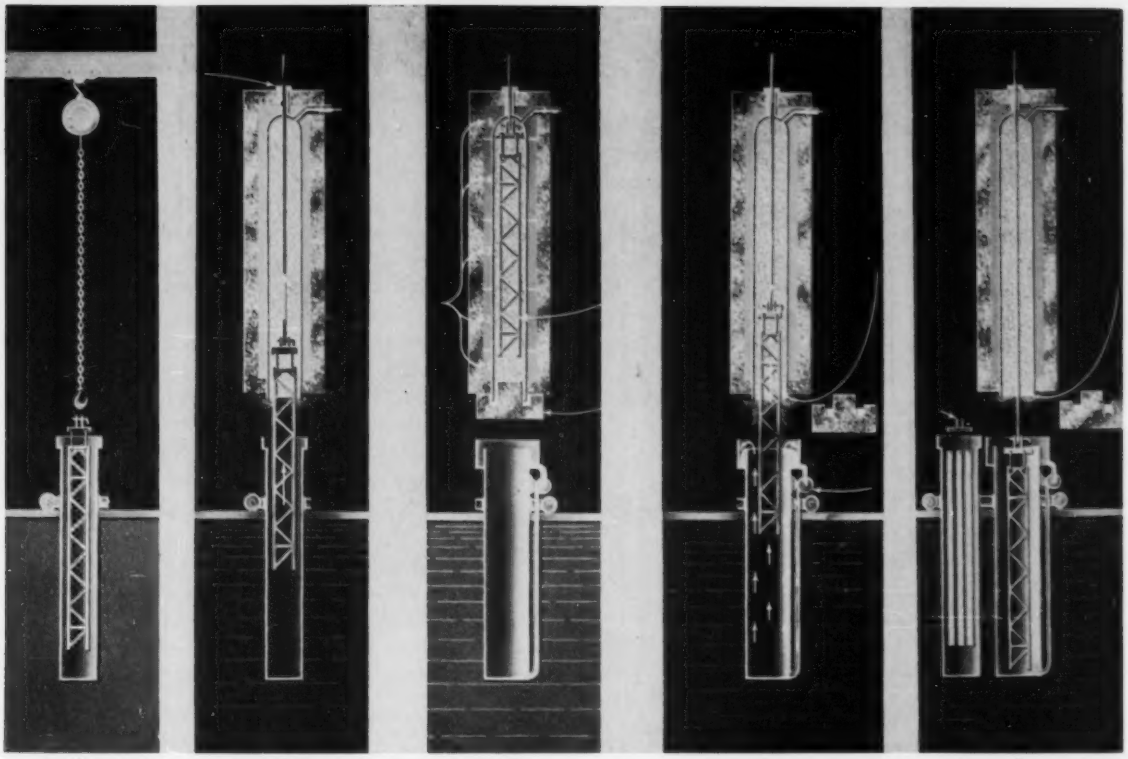


Fig. 1—Diagrammatic View of Inverted Pit Furnace and Its Operation

A—Dry well. Load, for example, aircraft tubular steel wing beam, straight tubes for hardening or tubular rocket body, first lowered into dry well;

B—Dry well moved under furnace. Alloy rod or other lifting mechanism lowered through stuffing box in top of furnace, engages spider from which load hangs. Spider and load are pulled straight up into the furnace. Furnace may be electric or, as shown here, gas fired, having a cylindrical retort of alloy steel provided with a plug at the lower end for closing. Picture shows special atmosphere gas inlet at the top which vents at the bottom and clears retort of all objectional atmosphere;

C—Work hangs straight and true, vertically suspended in furnace which is regulated in 5 zones from bottom to top, including one zone for the door, one zone for the top end, and three zones for the intermediate height containing the charge;

D—When ready for quenching the bottom door or plug is lowered and moved to one side, charge is lowered straight down into the quenching tank beneath. Tank is provided with recirculating pump which causes oil to flow upward in the tank, flushing over superheated oil to an overflow drain at the top from where it is returned to storage tank for recooling. Fresh oil is drawn in from the storage tank, not shown.

E—Charge is disconnected and new charge, shown in loading pit at left, is moved under the furnace. After cooling in oil to the desired temperature, the charge is removed from the quench tank.

tained by dividing the yield strength of each by its unit weight or its specific gravity. This number has been called the Strength-Weight Factor. For example:—

	Yield Strength	*Sp Gr*	*S.W.F.*
Aluminum Alloy	60 thousand psi	2.77	22
Alloy Steel	200 thousand psi	7.85	25

The steel is therefore *lighter* than the aluminum in the ratio 25/22 or 1.13. For highly special alloys the following might be typical:[3]

	Yield Strength	*Sp Gr*	*S.W.F.*
Aluminum Alloy (7075-T6)	66 thousand psi	2.80	23.5
Alloy Steel	240 thousand psi	7.85	3.0

Here, a super-strength steel is 31.0/23.5 or 1.3 times lighter than the highest strength aluminum alloy sheet. Moreover, it is usually true that the ratio of fatigue strength or endurance limit to yield strength is much higher for steel than for aluminum alloys. The latter also are more adversely affected by elevated temperatures than are steels. Aluminum alloy sheet resists flexure more than steel of equal weight because it is thicker (bending moment).

Various other strength-weight factors may be considered, based upon such engineering properties as ultimate strength, fatigue or endurance limit, strength at elevated temperatures, and modulus of elasticity (resistance to elastic deformation). The design engineer will also be concerned with ductility (toughness, resistance to shock or overload); fabricating qualities (machining, forming, joining, welding, etc.); resistance to corrosion; non-magnetic qualities; and cost and availability, etc.

Nevertheless, where a moving body must overcome inertia and gravity, lightness as determined by strength-weight-factor is usually the primary consideration.

[3] Guaranteed minimum values

Based upon available yield strength, endurance limit, strength at elevated temperatures and various other factors, alloy steels are usually the designer's logical choice for rocket bodies.

These steels ordinarily develop their strength by full heat treatment; namely, heating above the critical temperature (austenitizing), rapidly cooling, as by quenching, and then tempering for toughness. Certain special alloys (stainless steels, 17-7 PH, etc.) may be given high strength by cold work or by age hardening treatment, thus avoiding the troublesome quench; but they usually present offsetting drawbacks. Some special, very high alloy steels are hardened by cooling in air instead of liquid quenching, thereby simplifying heat treatment; but again there are serious offsetting drawbacks, especially in welding.

Heat Treating Problems

Since high quality alloy steels as developed for aircraft construction still are, and presumably for sometime will be, the optimum material of construction for rocket bodies, fuel chambers and the like, the problem of satisfactory heat treatment is a basic one.

Rocket bodies consist, with few exceptions, of a thin-walled cylindrical tank having head and tail attachments determined by the requirements of use. Liquid fuel tanks are simply provided with dished heads and outlets. Solid-fuel containers ordinarily have a head for the accommodation of instruments and charge and a tail nozzle for propulsion. Each of these three basic structural parts must be as light as possible, consistent with its form and functions; but the cylindrical body is the most exacting. It is sometimes heat treated with or without head and tail attachments in place.

When steel is heated to high temperatures, it softens and expands. However, on passing through the critical or transformation temperature range, plasticity is increased, expansion temporarily ceases, and some contraction may take place. All of this renders the body very easily deformed under its own weight.

To harden the metal and impart high strength, the steel must then be rapidly cooled or "quenched." During this fast cooling the metal is subjected to thermal shock, including severe stresses resulting from normal contraction. But there is an additional complication because, when the steel cools through the reverse transformation, there is a momentary expansion of volume which is then followed by normal contraction as the piece cools to room temperature. Variations in cooling rate due to thickness may cause contraction and expansion to occur simultaneously in adjacent sections. All this tends to deform, if not rupture the body. Small, permanent changes in mass, usually expansion affecting average diameter and overall length, may result from this metallurgical conversion. Also, shrinkage may occur at welds.

Designers not versed in metallurgy can therefore readily understand that the prevention of harmful deformation while quenching a rocket body which consists of a long, thin-walled cylinder, possibly with relatively thick end attachments, without causing harmful deformation, presents extraordinary practical difficulties.

After quenching, the part is tempered for stability and toughness. By proper skills, the heat treater can, in *tempering,* make some minor corrections in such deformations as unavoidably occur in the quench. He can also remedy some bow and out-of-roundness in the raw body, thus helping the fabricator.

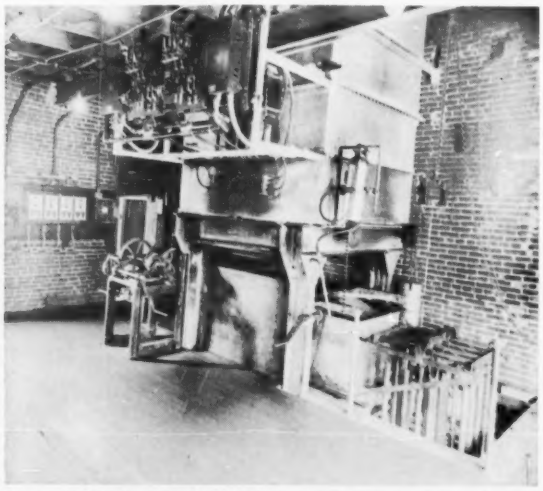


Fig. 2—Original inverted pit furnace in the METLAB CO. plant in 1928. Heating space was 3' x 3' x 10'. Used for heat treatment of tubular aircraft axles and other components. Electrical 4-zone control with oil quench;

Dimensional Tolerances

Forged heads and nozzles should be made with an allowance for light, final machining after heat treatment, permitting very accurate assembly fits. No machining is permissible on the thin-walled shell or dished head. They must therefore be held within whatever tolerance is allowable.

Welded seams contribute to irregularity of contour and tend to cause local contraction. Residual strains from prior cold work contribute to deformation in heat treatment. These factors are beyond the heat treater's control, but he can advise as to their prevention.

The Principal Problem

The control and prevention of deformation within permissible tolerances is the principal problem in body manufacture. This problem is within the province of the skilled metallurgist and heat treater to solve. Closer tolerances present greater difficulties and therefore increased costs.

It is here that the art and skill of the heat treater become the determining factor even though the best furnace facilities may be available. (Some people can get better music from a Stradivarius than others.)

Rocket engineers should give most careful consideration to tolerances specified in design. They should

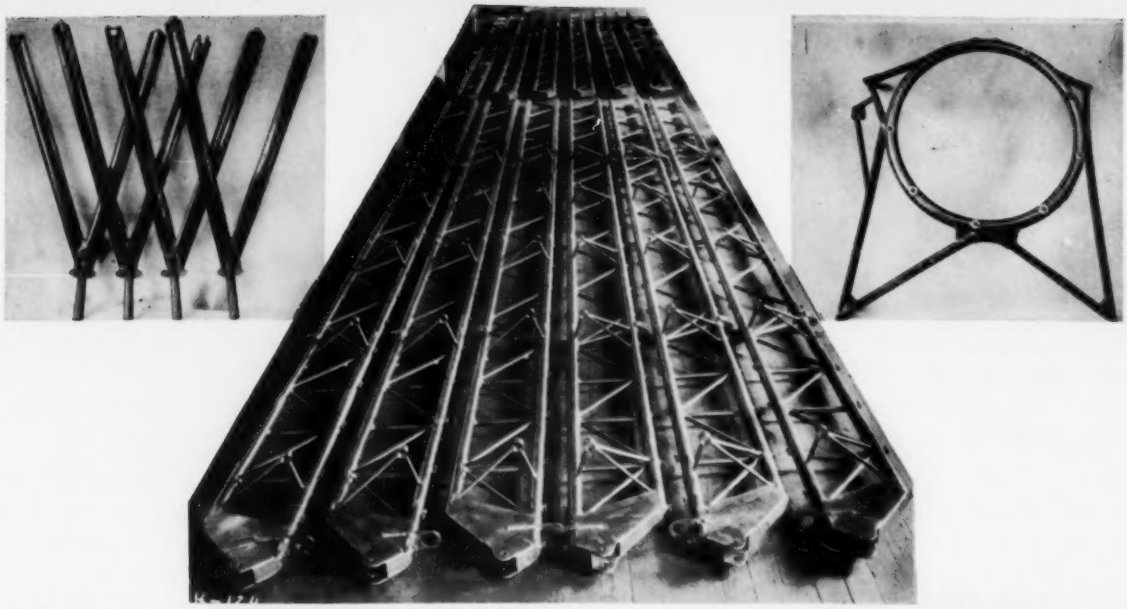


Fig. 3—Early delicate aircraft structural members requiring high strength, lightness and dimension accuracy; heat treated in original inverted pit furnaces;

Upper Left—Aircraft landing gear; streamline tubing steel 4130 X; 150,000 psi Ult. strength; tolerance plus/minus 1/32";

Center—Wing spars for 1930 Stinson trimotor transport plane; 22' long; 180,000 Ult.; Steel 4130 X; straight to ¼" in full length;

Upper Right—Small aircraft engine mount; 180,000 psi Ult.; 4130 X; tolerance plus/minus 1/32";

consider the limits required to insure *adequate performance* and not whimsically specify closer limits. Purchasers should then insist on compliance with these requirements. Otherwise, they will either unnecessarily increase the cost of production or have to waive dimensional tolerances which have not been practical to meet. Experience in the rocket and missile field since its inception has convinced the writer that this important factor has not been fully appreciated by design engineers, with resulting serious detriment to the industry in many ways.

To specify a closer tolerance than justified by performance requirements places an unnecessary burden upon the fabricating shop and especially the heat treater. If these latter know their business, the problems of meeting these tolerances will be reflected in their bid. Too frequently, however, excessively close or impractical tolerances are set up, only to be ignored or waived when difficulties are encountered in meeting them. Then the purchaser does not even get as close tolerances as he might have had, with consequently inferior performance; meanwhile the competent fabricator and heat treater who appreciated and allowed for the extra costs involved, lost the job they were entitled to.

Cold Work

It is very undesirable to attempt to correct deformation in a high strength body, after heat treatment, by cold work. This process leaves internal residual stresses which detract directly from the effective strength of the metal, possibly causing premature failure in service, stress-corrosion or gradual re-deformation due to release of stresses with time. Any attempt at post-heat treat correction by cold work should be followed by an adequate retempering treatment.

Inverted Pit Furnace

The extreme difficulties involved in quenching large, thin-walled rocket bodies to high strength without ruinous deformation have resulted in the almost universal adoption of a furnace of special design, variously called "drop bottom", "gantry" or "inverted pit." The latter name appears to be the most descriptive. There are about twenty such furnaces in use today, and additional ones are planned. They consist essentially of a vertical heating chamber having its door in the bottom, the top being sealed. A clevis rod, alloy chain or other lifting device moves down inside the furnace and engages a spider supporting the charge which has previously been placed in position on a rack below the open door.

The spider and charge are then gradually raised into the heating chamber and the bottom door or plug is closed. While heating, the charge hangs vertically, being carefully supported with fixtures in such a way that sag under its own weight is avoided. (See Fig. 1).

Great care is taken, by proper controls, to insure accurate and uniform temperature in the heating chamber. To avoid scale or surface decarburization, special artificial atmosphere is provided. Electric furnaces

(Continued on page 34)

PROGRESS IN INDUCTION HEATING

By **D. H. LAPRAY**
Industrial Heating Department
General Electric Company
Shelbyville, Indiana

NOT LONG AFTER the discovery of electricity, scientists found that when a current of electricity flows through a conductor it heats. They also found that when a magnetic material is placed in an alternating current field, heat is produced in the material. This process became known as magnetic hysteresis.

It was not until early in the nineteenth century that any mention was made about induction heating in any literature. About this time Michael Faraday completed a series of experiments with coils of wire carrying alternating electric currents. He recorded in his data that when an alternating-current-carrying coil was inductively coupled to another coil, a voltage was induced into the second coil. This was the birth of the transformer.

Others found that the addition of a magnetic circuit added to its workability. Early scientists recognized the heating phenomena and compensated for the losses in their electrical apparatus, but did not consider it a useful tool.

Shortly after the middle of the nineteenth century, a series of patents were issued describing the use of induced currents for heating metals. Most of these concerned themselves with inductive heating of graphite or a metallic crucible to a temperature above that of the charge. The heat from the crucible melted the charge by thermal conduction.

By the late 1800's, Ferranti and Colby presented data for an induction melting furnace which induced currents directly into the charge, thereby permitting the use of non-conducting crucibles for hearths.

Additional work on the Colby design by Kjellin eliminated certain difficulties and improved the efficiency of operation of this furnace. The original furnaces operated on relatively low frequencies, ranging from five to 60 cycles. No means was available at that time for producing a large amount of electric energy at high frequencies.

About 1916 Dr. E. F. Northrup invented the high-frequency melting furnace in which the material to be melted was placed in a retaining crucible of non-conducting material. This is sometimes referred to as a coreless induction furnace. In addition, he developed the spark-gap converter for high-frequency power. It was not until about 1925 that mention was made in scientific literature pertaining to the use of induction heating for other metallurgical applications. In fact, except for induction melting of metal, there were relatively few commercial installations of induction heating prior to World War II.

Principles of Induction Heating

In action, induction heating is very spectacular. If a cold bar of steel is placed into an inductor coil (a cold, water-cooled coil of copper tubing attached to a high frequency power source), the steel will become red hot almost instantaneously, then incandescent, and finally will melt into a molten pool. The amazing thing about this demonstration is that the object being heated does not actually come into physical contact with the inductor coil surrounding it. Functionally, what we have is nothing more than a transformer. The inductor coil acts as a primary of a transformer; the steel shaft acts as a shortened turn secondary. Due to a phenomena sometimes called "skin effect" this induced current is concentrated into a thin section on the periphery of the charge. This high current concentration, combined with the resistance of the material,

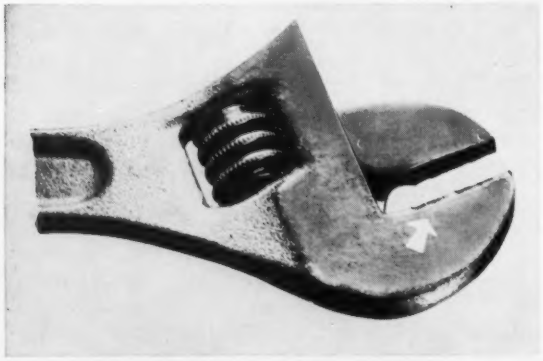


Fig. 1—Forged steel wrench after normal use

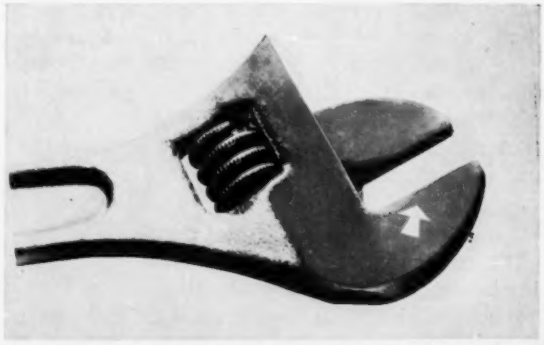


Fig. 2—After more rugged usage, wrench jaws of induction heated unit show no wear

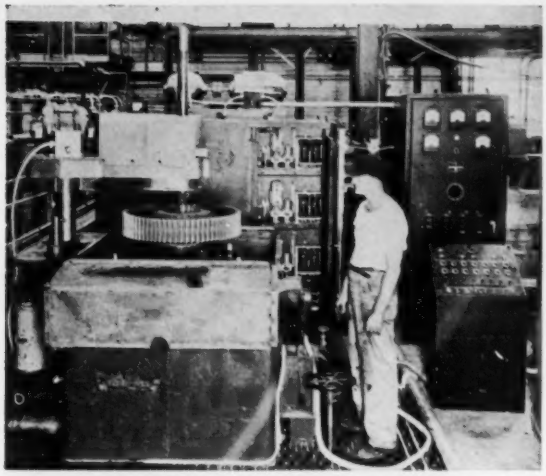


Fig. 3—Gear hardening with motor-generator induction

causes an I^2R loss which appears as heat. In addition, if the charge is a magnetic material, heat is also generated through hysteresis losses. The depth of current penetration is a function of frequency, permeability and resistivity. Since permeability and resistivity are both functions of the charge material, we will concern ourselves only with the effect of frequency at this time.

The depth of current penetration is an inverse, square-root function of the frequency. As the frequency increases, this depth decreases. This factor is an important consideration in selecting the proper equipment for any given application.

In general, for thorough heating of materials the lower frequency spectrum is used. For selective heating the higher frequency spectrum is used. The most commonly used frequencies are 60 cycle (from commercial power lines); 1000 cycles, 3000 cycles, 4200 cycles, and 10,000 cycles (from motor-generator equipment); and 200,000 to 450,000 cycles (from electronic oscillators).

There is increased interest in the one-to-five megacycle frequency range for use with very thin materials and semi-conductors such as germanium and silicon.

Fig. 4—Gear hardening with electronic induction

Some 180 cycle and 360 cycle equipment is also being used now.

The specific metallurgical applications of induction heating are melting, forging, hardening, annealing, drawing, normalizing, metal joining, and metal purification. As stated earlier, the first practical applications for induction heating were for melting metals.

Improved versions of the early core-type induction furnaces are used commercially today. The core-type furnace is manufactured in capacities ranging from a few hundred pounds to several tons. It is used both for holding molten metal at temperatures as well as for primary melting.

Hardening of Steel

A very important application for induction heating is hardening of steel. You and I profit every day from the fact that special methods of hardening steel have been developed. Look at the jaws of the wrench in Fig. 1. It is made from forged steel and has been submitted to normal use. Note the irregular surfaces of the jaws. The second wrench in Fig. 2 was used 17 times the number of applications as the first, yet no burrs or marks are evidenced. The reason is simple. The jaws have been selectively hardened with an electronic induction heater.

Hardening of steel can be broken down into two general categories;—through hardening and selective hardening. Induction heating is most adaptable to selective hardening. Items which fall into this classification include gear teeth, bearing surfaces, wrench jaws, cam surfaces, cylinder liners, mowing-machine blades, lathe beds and a multitude of others.

Selective hardening can be accomplished in a number of ways. These include nitriding, cyaniding, liquid carburizing and carbo-nitriding. All of these processes are relatively slow and in some cases require very special steels. The fastest growing method of selective hardening is induction hardening. The principal reason for this is that only the section to be hardened is heated and quenched. Cheaper grades of steel can be utilized. In general, large parts such as large gears, crank shafts, straight shafting axles, etc., are hardened with motor-generator induction heating equipment. Electronic induction heating equipment is used for small parts or other parts requiring a very thin case.

A 1000 cycle generator will induce a surface current which will harden the outside shell of the part to an average depth of from 100 to 500 thousandths of an inch; 10,000 cycles will normally harden to a depth of from 50 to 250 thousandths of an inch, and 450 kilocycles will harden from 10 to 90 thousandths of an inch.

In order to heat these surfaces to be hardened to hardening temperature before the heat can conduct too far into the part, it is necessary to use very high power densities. If the depth of hardened case is to approximate the minimum values for a given frequency, it is necessary to have a power density of 5-10 KW per

square inch. On certain types of parts such as axles, shafts, etc., it is possible to reduce the size of the equipment required to obtain a given case by progressively hardening the parts. Some typical applications for induction hardening are shown in Figs. 3 and 4.

In Fig. 3 we have here a large gear being hardened by motor-generator induction equipment. This could be done either single shot or by progressive hardening.

A typical arrangement for small production lots is shown in Fig. 4. In this case electronic oscillators are being used on a single position operation. The gear shown at the left is manually placed on a rotating-elevating device, and lowered into the inductor coil where it is heated and quenched in oil. It is then raised for the operator to remove.

The machine in Fig. 5 uses a different approach to gear hardening. Here the hardening is done one tooth at a time. This has the distinct advantage of being able to use a relatively small power source to harden large gears. This operation is being performed at the New Britain Machine Company, New Britain, Connecticut. One operator takes care of two of these units simultaneously.

A semi-automatic valve tip hardening machine is shown in Fig. 6. Here the valves are loaded onto a conveyor, progressed through an induction coil, and oil quenched. Production rates in excess of 4000 parts per hour have been obtained with this equipment.

Fig. 7 is a close-up of an automatic machine for induction hardening of automotive push rods. This is sometimes combined with another induction heater for heating the ends of the rods for upsetting, and then followed by the induction hardening as example of in-line automation.

Fig. 5—Tooth-at-a-time gear hardening

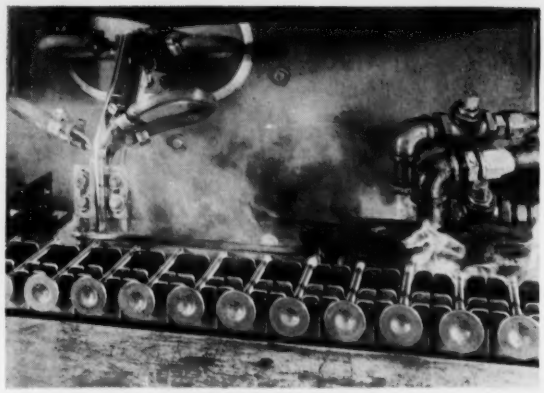


Fig. 6—Hardening valve tips

The ease with which induction heating equipment can be automated and the small floor space required makes it very convenient to install directly in an assembly or production line. One such installation is a completely automatic machine for hardening a broached part for use in an automatic transmission. This machine is fed from an automatic storage type feeder from which the parts are heated and quenched and conveyed to a draw furnace. This is just one of several such induction heating machines which will be installed in the complete production line for the automatic transmission. It is sometimes convenient to combine both the hardening operation and the draw operation on the same machine.

While many of the hardening applications illustrated are production line equipments, we must also consider that induction heating can be a very valuable tool for case hardening of small lots. One example is illustrated in Fig. 8. This illustrates the variety of parts that are being handled on a single machine.

(Continued on page 14)

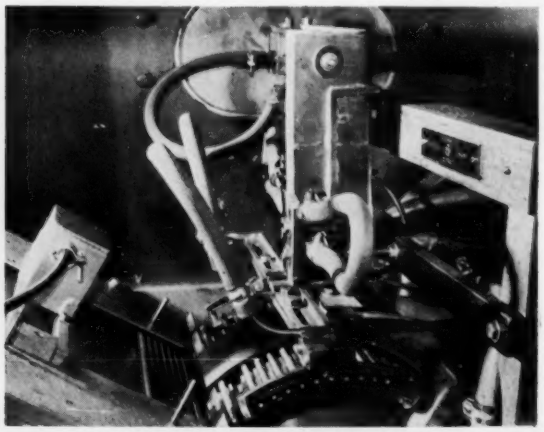


Fig. 7—Automatic hardening of push rods

Pacific* ROTARY HEARTH FURNACE

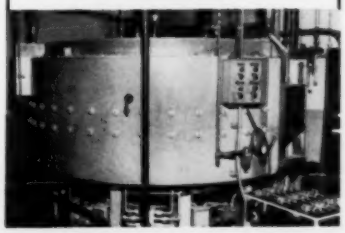
Preheating crankshafts, gears, and other precision parts where final dimensions must be held within close tolerances has proven a profitable operation for McCulloch Corp. – using a Pacific Rotary Hearth Furnace!

This highly efficient, continuous furnace requires only one operator... to load cold parts and remove hot ones for quenching. Even this job can be taken over by automatic charging and discharging mechanisms if desired! The furnace has controls to vary the speed of the rotary hearth from 15 minutes to 1½ hours. It is also equipped to automatically stop at pre-set positions to speed up the loading and unloading operations. The position may be varied as the parts vary.

Widely used for forging, annealing, heat treating and drawing of ferrous and non-ferrous metals where large production rates are a factor, the Pacific Rotary Hearth Furnace has a record of top performance in many plants. Various sizes and capacities with temperatures to 2000°F are available. Call Pacific Scientific now... for a rotary hearth furnace that will be just right for *your* specific job.

DESIGN FEATURES... FOR GREATER EFFICIENCY, MORE ECONOMY!

- Oil sealed hearth with adjustable speeds
- Floating hearth plates
- Automatically controlled uniform temperatures
- Various sizes and capacities available
- Temperatures to 2000°F
- Automatic charging and discharging devices available
- Rated at 90KW with two zones of control. Preheat zone is rated at 60KW and holding zone rated at 30KW.
- Door has flame curtain to prevent infiltration of air to furnace when open.
- Endothermic atmosphere is used to prevent decarburization during the heating cycle.



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(Continued from page 12)

Metal Joining

Another important application for induction heating is metal joining. Approximately 35% of all electronic induction heaters purchased are used for this purpose and a significant percentage of motor-generator equipment is also applied here. It is conceivable, based on known installed capacity of induction heaters in the United States, that as much as 500 tons of steel product and many hundreds of tons of non-ferrous metals are joined together every hour by induction heat.

Let us consider the advantages of joining metal with induction heating. First, it is selective. By proper coil design, induction heat can heat the metal in the immediate area to be joined. Very little heat is wasted and undesirable metallurgical changes, such as oxidation, annealing and grain growth do not occur in the rest of the piece.

Fig. 8—Small lot parts handled on a single machine

Second, it is reliable. Induction is not bothered by such variables as operator fatigue, consistency of gas, and human skill. Once a heater is set up properly, production rejects are reduced and the production output becomes essentially uniform in quality and quantity.

Third, it is clean. Other than flux fumes from the brazing or soldering operation, there are no products of combustion. The working area around an induction heater becomes a desirable place to work, often the show place of the plant.

Fourth, it is economical. Even though induction is one of the most expensive forms of heat, economics realized through its selective heat characteristics: better product, improved working conditions, savings in costly materials such as silver solder, more than compensate for its relatively high original cost.

Fifth, it is a high production tool for many types of brazing and soldering operations. Time and again induction heat has been able to step up production many fold and at the same time reduce the per unit labor cost.

Fig. 9 is a good example of combining atmosphere soldering or brazing with induction heating. This specific application allowed the user to solder some small missile parts which previously had proven difficult to solder without damage to adjacent areas. This is a four-station operation, and either vacuum or multiple combination of gases can be used.

Annealing

Induction heating also lends itself very nicely to both selective and continuous annealing of both ferrous and non-ferrous materials. It gives very precise control, uses a small floor area, and in general is much cleaner than other heat sources. One example is the continuous annealing of steel tubing after it comes from the forming rolls. Still another application is the heating of this metal strip for tin reflow or annealing.

Fig. 9—Brazing and soldering in protective atmosphere

This article has briefly described the history, theory and applications of induction heating in the laboratory and in industry. Properly applied, it can produce substantial cost savings, improved product, improved working conditions, and, in many cases, enable the manufacturer to perform operations which are not practical by any other type of heat source. • • •

AUGUST—Selected supplier of anhydrous ammonia . . . assuming that service included technical advice "during use".

LATER—Ammonia system installed without supervision . . . not tested by supplier . . . some parts not designed for ammonia use.

STILL LATER—Had improper atmosphere mixture . . . undesirable case properties . . . sooting and added handling of "finished" parts.

TOO LATE—Too many rejects . . . supplier unable to aid on application. Labor, material and operating costs up . . . profits down.

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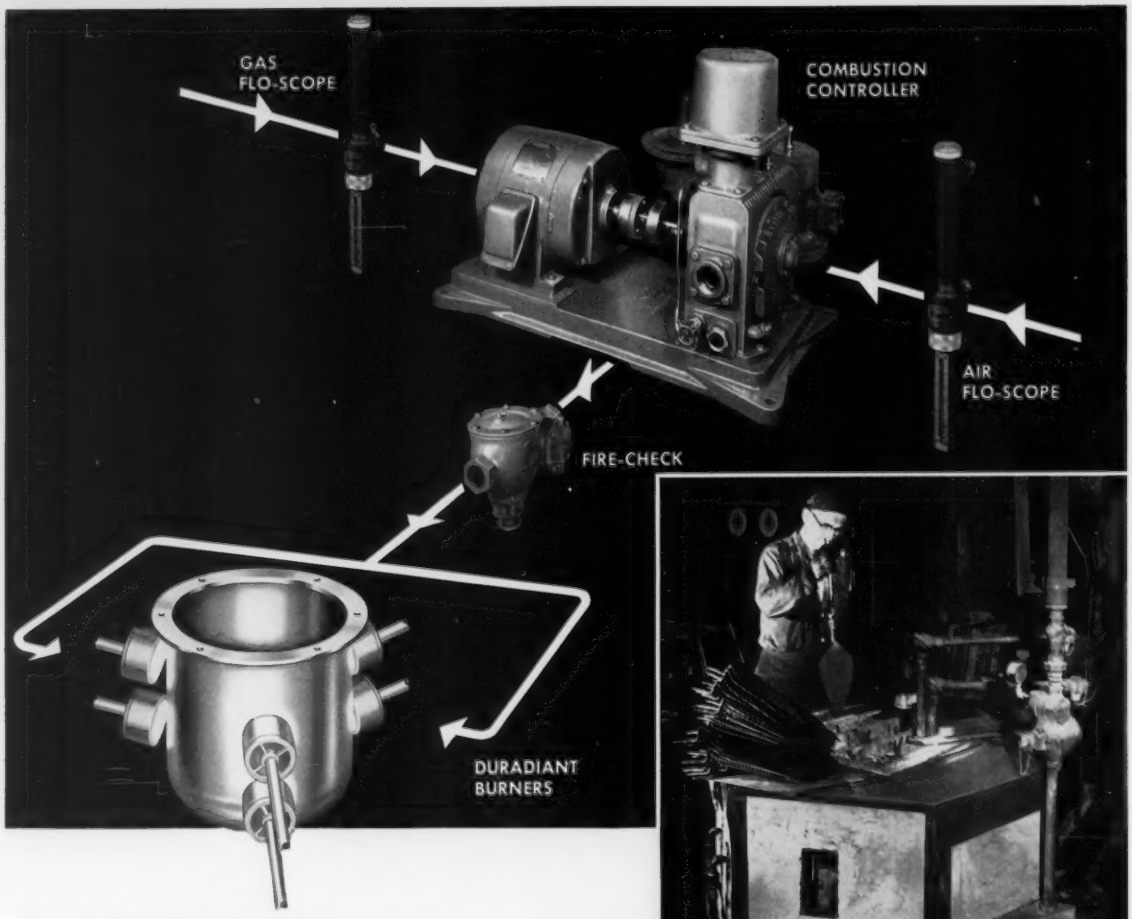

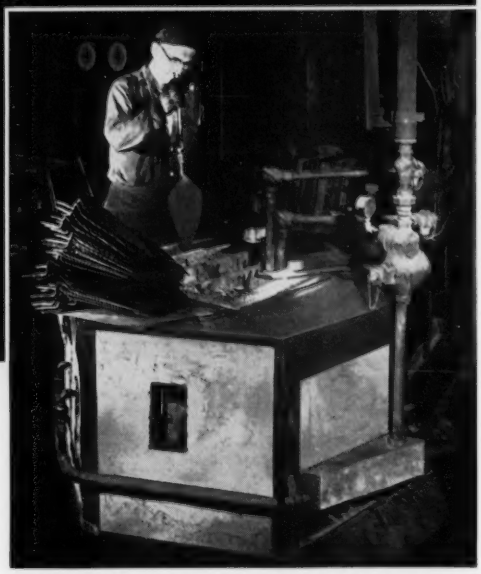

Lead bath is brought to heat in only 1½-2 hr with Duradiant burners; former method required 3-4 hr. Pot life is extended up to 10 times: 36 hr per yr saved on pot repair work.

Selas Duradiant® Burners Increase Pot Life up to 10 Times... Reduce Fuel Costs 20%

Wm. Rose & Bros., a leading manufacturer of trowels and steel tools, recently converted all of its heat-treating operations—shaping, forging, hardening, tempering—from oil heating to Selas gas-fired burners.

The faster, more uniform heat provided by the Duradiant burners—without direct flame impingement—is providing 20% savings in fuel costs . . . lengthening pot life 8 to 10 times . . . saving as much as 2 hr bringing lead bath to heat for hardening. Faster heating is also assuring finer grain structure in steel parts after heating for forging . . . and is eliminating scale formation.

At Wm. Rose & Bros., and throughout the metalworking industry, Selas provides a complete combustion package to assure most efficient operation of Duradiant burners:

- Combustion Controller—makes possible fast heating and close control, by delivering gas-air mixture to burners at preset ratio and pressure. Completely automatic; no labor required in its operation. Factory Mutual approved.
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Standard Duradiant burners can be utilized in open arrangements . . . in-line . . . in circular rings . . . in spirals . . . individually . . . in opposed pairs. Special Duradiant designs can be custom-built to meet your specific needs.

Selas also offers other types of burners including Superheat, Refrak, Spear-Flame and Ribbon.

These combustion components are available individually or as a complete combustion package.

For descriptive literature on any of the above combustion components, write Dept. 611, Selas Corporation of America, Dresher, Pa.

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Here you see the dramatic action of Park Chemical Company's AAA Quench Oil, a faster cooling yet extremely long-lasting quench oil. Park AAA provides higher and more uniform hardness, with little or no distortion, warping, or cracking. To quote Merle Hoensheid, General Manager of the Stephenson Highway plant of the Commercial Steel Treating Corporation, Detroit: "We have learned to *depend* on the more than satisfactory results from Park's AAA quenching oil."

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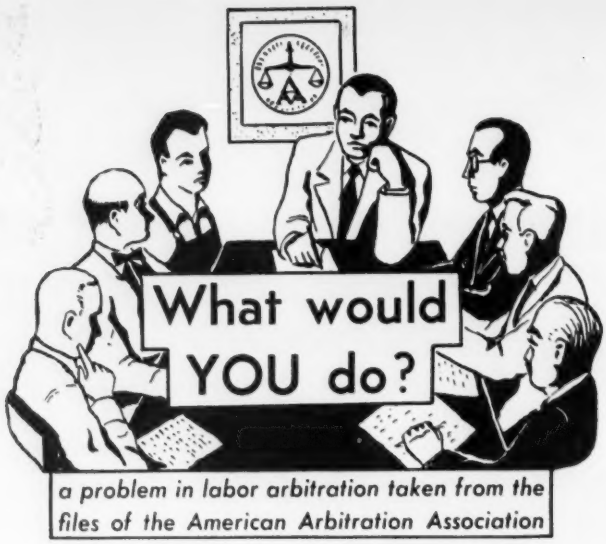

The Case of the Overworked Watchmen

Toward the end of 1958, a shoe manufacturing company in New Hampshire leased one of its buildings, which had formerly been vacant and unattended, to a leather findings corporation. The corporation agreed to buy leather scraps from the footwear company; otherwise it was a landlord-tenant relationship between two independent firms.

This new arrangement led to a change in work assignment of watchmen. They now had to patrol the inside of the leased building, in addition to their usual duties in the shoe factory.

"That isn't fair," they complained. "The findings company is an independent outfit. We're not on their payroll; why should we have to do work for them?"

"You have nothing to complain about," answered the personnel manager. "We shortened your patrol duties around the shoe plant to compensate for your new duties at the findings company building. I can't see how that makes any difference to you."

The union admitted that the watchmen didn't actually have more work to do, but it was a matter of principle. So the dispute went to arbitration under the rules of the American Arbitration Association.

What Would YOU Do?

THE AWARD: The arbitrator said that even though patrol time was not increased, the company had no right, under the contract, to assign men to work on the premises of and under the supervision of another company. "To uphold the company position would be to ultimately sanction the assignment of employees to any plant owned by the other company, irrespective of its working conditions, location, or job workloads, solely upon the ground that the company has contracted to supply service to another company," he said.

The Case of the Job-Grabbing Handyman

Stanley D. held down a job as maintenance mechanic in a metal wire and screen plant and, at the same time, conducted quite a thriving contracting business on the side. It seemed that whenever a home owner in the neighborhood needed a new garage built, a lighting system installed or a driveway cemented, he would call on Stanley to do the job. During 1958, Stanley had so much work of this nature that he not only absented himself from work quite often but had to hire a part-time laborer to help him out.

Management was getting a bit fed up with this state of affairs. And so when Stanley telephoned one day early in 1959 to say that he'd be out, the personnel manager decided to fire him. The union promptly filed a grievance, claiming that the reason for Stanley's absence that day was his wife's illness. "I wanted to explain that to the watchman who got my call," Stanley testified, "but he hung up on me."

"We don't believe it," answered the personnel manager. "You're trying to misrepresent your absence, which is just another reason why you deserve to be fired. And if the watchman did hang up on you, how come you didn't call him back to offer your explanation?"

At this point the union's international representative cut in: "This issue of the telephone call really has nothing to do with it. You didn't fire him because of alleged misrepresentation, you fired him because of his outside work. But that's something you've known about and tolerated all along. So what gives you the right to get tough about it all of a sudden?"

After all the arguments and evidence were in, the arbitrator declared the hearing closed, in accordance with the rules of the American Arbitration Association, and retired to make his decision.

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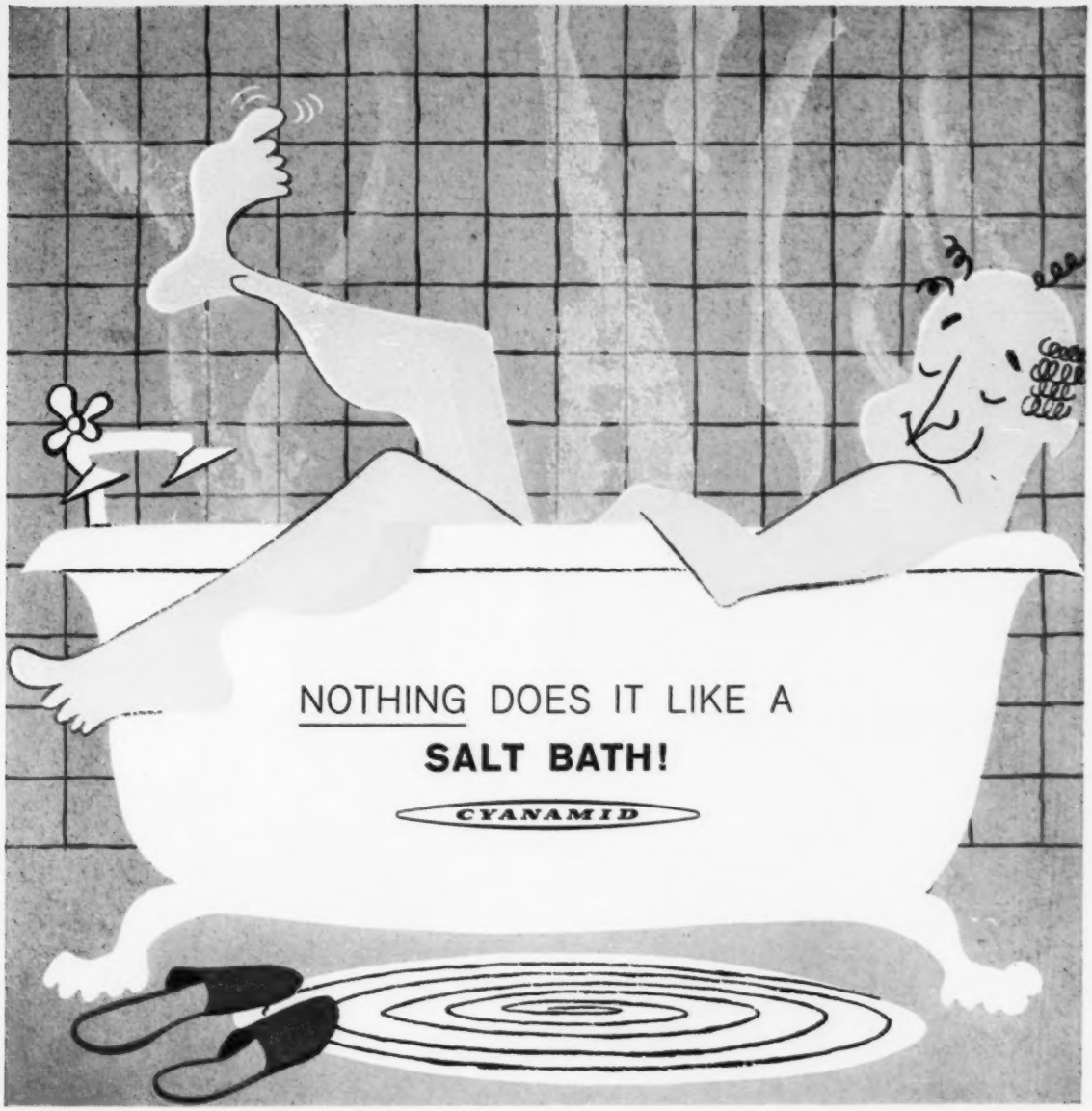

There are other ways to heat treat metals, but nothing quite compares in *deep-down, over-all, satisfying* results with a Salt Bath.

For one thing, salt furnaces heat work faster and more evenly because temperatures are uniform throughout the bath. Too, salt baths *eliminate* scaling and decarburization without the use of special atmospheres . . . even from bath to quench since a thin protective layer covers the metal. Partial immersion of the work also allows selective heating.

With all of this, initial *costs,* operating costs and maintenance costs are low. Long pot life means less down time; high thermal efficiency means low operating expense. Mechanization saves labor costs, increases production.

Why not check with your *Process Chemicals* salesman and learn of the "engineered advantages" of Cyanamid's highest quality heat treating salts—or drop us a line. Then, put your heat treating, case hardening and carburization jobs into a bath filled with Cyanamid Salts, settle back and enjoy the satisfaction of a job well done.

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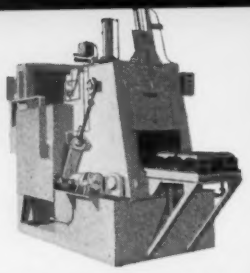
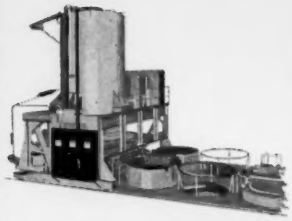
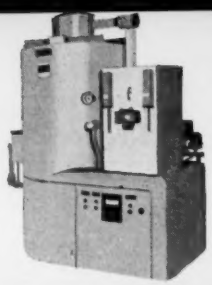
Laboratory Equipment: **One-unit box furnace (shown), muffle or for non-oxidizing atmosphere with temperature range to 3000° F.**



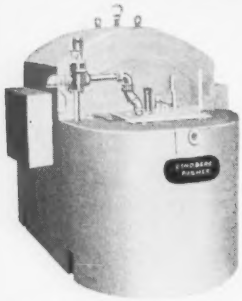
Automatic Carbonitriding Furnaces: **Automated integral quench type (shown) with CORRTHERM electric elements.**



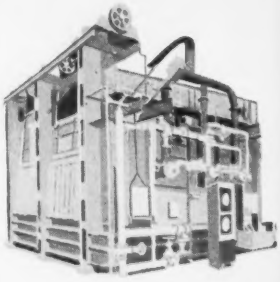
Gantry Type Furnaces: **Vertical, controlled-atmosphere, drop bottom, hardening furnace (shown). Complete installation field-installed by Lindberg.**



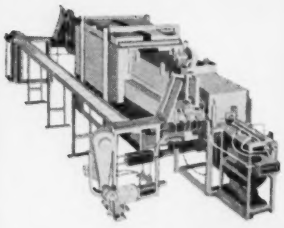
Atmosphere Generators: **Hyen generator (shown) for endothermic atmospheres. Generators for all required atmospheres.**



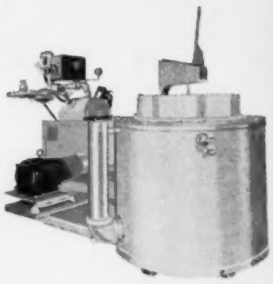
Melting and Holding Furnaces: **Electric resistance furnace (shown) with capacities of 750 lbs. to 1500 lbs.**



Aluminum Reverberatory Furnaces: **Twin-chamber melting and holding furnace (shown) with 45,000 lbs. capacity.**



Ceramic Kilns: **Fully automatic, atmosphere controlled kiln (shown) has 5 control zones for flexibility. Maximum temperature, 2700° F.**



Cyclone Tempering Furnaces: **Batch type fuel fired tempering furnace (shown). Famous in metal treating industry for years.**

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Applying heat to industry has been our only vocation for many years. When your product needs heat it makes sense to consult the most widely experienced experts you can find. We believe we have them here at Lindberg. First of all, we manufacture a full line of equipment, the most complete in the field; heat treating furnaces, salt bath furnaces, melting furnaces, induction heating units, ceramic kilns, laboratory and pilot plant furnaces—electric or fuel fired, built in our plant or field installed. So, we can recommend just the correct techniques best suited to your individual requirements and your production methods. Here at Lindberg we have an exceptionally creative group of metallurgists, research technicians and engineers, the best in the business, we vow. You can count on them to answer your industrial heating problems satisfactorily, no matter how complex or unusual. Our world-wide organization, with plants and subsidiary companies in many countries, makes this superior service available to you anywhere.

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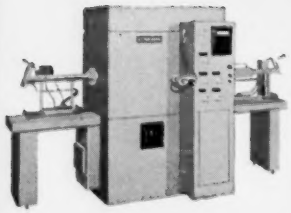
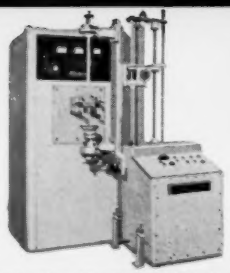
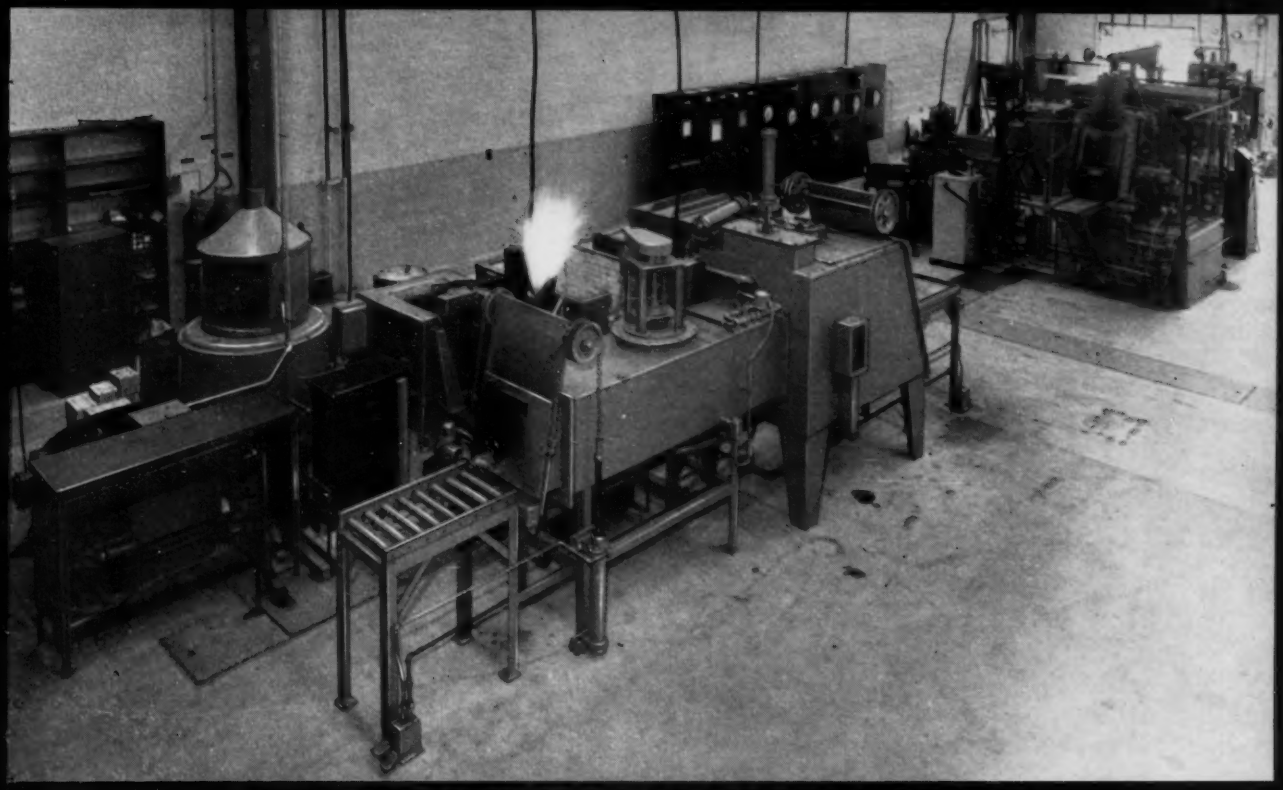
LINDBERG **heat for industry**



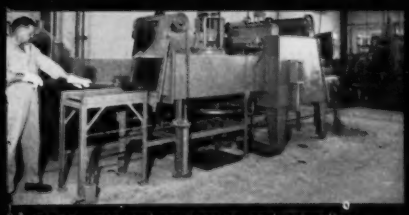
High Temperature Furnaces: **New Graphite Tube Furnace (shown) with temperature range 2600° F. to 5000° F. for research and production in metal and ceramic fields.**



Induction Heating Units: **New Lindberg Floating Zone Scanner for precise production of hyper-pure semi-conductor materials and metals and Induction Heating Unit (shown).**



General view of complete Heat Treating Department at new plant of Lear, Inc., Grand Rapids, Michigan. All equipment including furnaces, Hyen atmosphere generator, control panels, oil quench is by Lindberg.



Electric atmosphere brazing and annealing furnace. Hand pusher type . . . 2100° F. maximum temperature.

Electric pit furnace for treatment of high temperature alloys in dry hydrogen atmosphere. Tap transformer also shown.

The retort for high temperature pit furnace for treatment of alloys at 2200° F. (left). Production tempering furnace, 22" x 26" work space, shown at right.

Atmosphere tempering furnace, 16" x 24" work space, for both gaseous nitriding and steam treating. One retort in foreground.

LINDBERG Equips Complete Heat Treating Department at Lear, Inc.

The heat treating requirements for the new Grand Rapids plant of Lear, Inc., were put into Lindberg's hands. We supplied them in the way the photographs show. Our engineers cooperated fully with Lear in the selection of the proper Lindberg equipment and the layout of the complete heat treating department. This installation illustrates one of the big advantages of consulting with Lindberg. Our years of experience in all phases of the application of heat to industry, our complete line of all types of industrial heating equipment offer the best assurance that you can coordinate all your needs in one reliable, experienced source. Consult your local Lindberg Field Representative (see classified phone book) or write us direct.

LINDBERG **heat for industry**

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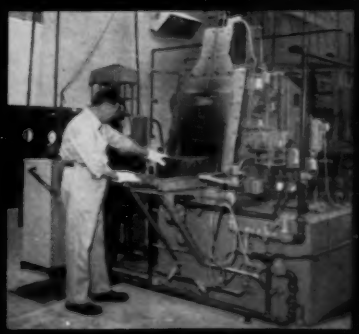

Integral quench furnace with CORRTHERM electric heating elements . . . for carbonitriding and general heat treating.

THE APPRENTICE CORNER

THE USE OF MEASURING INSTRUMENTS

In the long history of heat treating, one of the most perplexing and difficult problems was and still is distortion. The heat treater has applied many skillful procedures to minimize size change and distortion. "Heat Treating Hints" and "Apprentice Corner" departments have discussed examples of distortion and its correction in previous issues of *Metal Treating*. It is the intent of this article to suggest the importance of *when* and *why* to use measuring instruments during the heat treating process. All too often the heat treater believes that hardness testing is all the checking or testing he assumes responsibility for in connection with proper heat treat practice. This may, in specific cases, be all he is required to do, but a conscientious, skillful man does more than simple mechanical operations.

Excessive warp or size change may be just as costly as rupture of the part. It is not unusual that the tool room inspector notes these results on an inspection report, and very little is accomplished but ill will. Each one passes the blame on from one to the other. This can be avoided, quite simply, by requesting what dimensional change and/or distortion limits were left for heat treating. After these limiting factors are noted, the most important step to follow is to check the dimension BEFORE heat treating.

It is therefore necessary that the heat treater be thoroughly familiar with and able to use micrometers, verniers, height gages, indicators, plug gages, etc. Surface plates, straight edges, tool makers' angle, and benches for checking total indicator reading on rounds are all important heat treat department equipment. The ability to use such equipment does not necessarily insure the parts from deforming during heat treating, but the knowledge of knowing the amount of distortion after quenching aids the skillful operator to correct within requirements.

Heat treating deformation curves are available in the catalogs published by the steel companies. They are useful guides as to what average size change may be expected. Unfortunately, parts heat treated are often complex, and other factors affecting size change and distortion must be anticipated. Knowing exactly what distortion limits are acceptable and verifiable by the use of dimensional checking procedures before and after heat treatment enables the heat treater to save himself a great deal of trouble. Stress relieving, modified heating and quenching cycles, and fixture clamping during tempering are merely some of the techniques that may be required to do the work successfully. A wise precaution for the man at the fire is to be sure the job is right before he starts, and by checking dimensions, *you can be sure*.

Fred Heinzelman, Jr.
Fred Heinzelman & Sons

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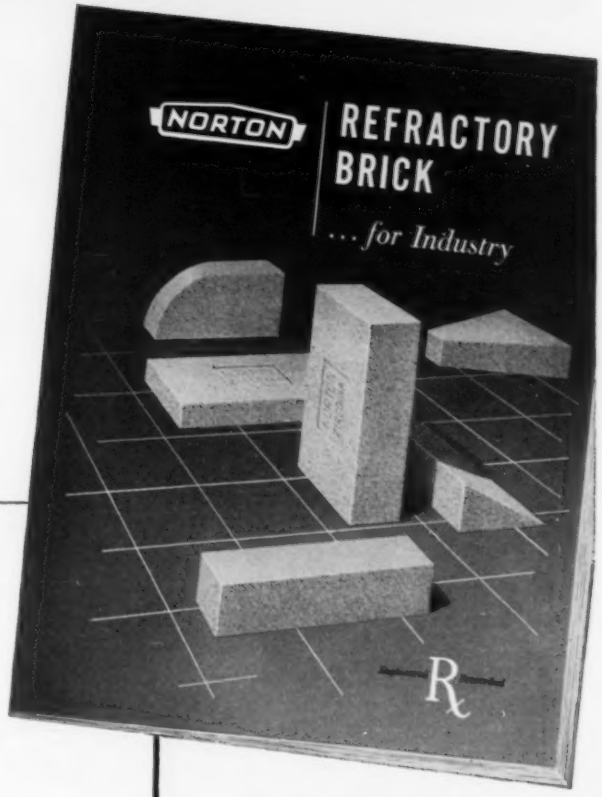
Send for this

New Booklet to Help Improve Your High Temperature Processing



Covers Norton refractory brick applications, characteristics, chemical analyses — includes helpful data on materials of construction for temperatures up to 4,400°F.

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All essential details are listed, such as: how each material is produced . . . important properties, characteristics and chemical analyses . . . shapes of brick and other molded products that are available . . . representative applications . . . packing methods that assure safe arrival.

Also included are charts and tables of brick shapes and sizes, thermal expansion and conductivity graphs, and a temperature conversion chart.

Norton refractories — engineered and prescribed for the widest range of applications — have helped many users save time and money. The ℞'s described in "*Norton Refractory Brick . . . for Industry*" may do the same for you. Write for your copy to NORTON COMPANY, Refractories Division, 630 New Bond Street, Worcester 6, Massachusetts.

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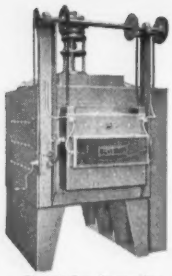
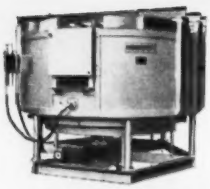


Electric Box Convection Furnace

Tool-Room Furnace with Quench



Electric Rotary Hearth Furnace

Graphite Resistor Tube Furnace

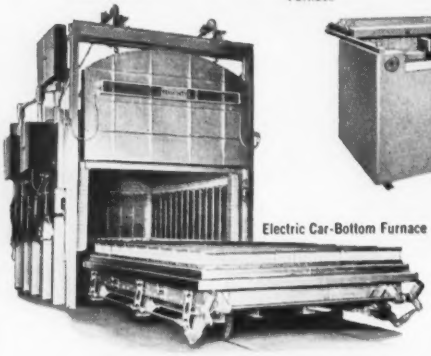
"Circ-O-Therm" Laboratory Oven

Rotating Tray Oven

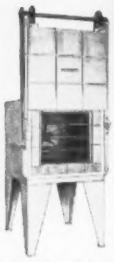
Coke or Ore Testing Furnace

Electric Endothermic Atmosphere Generator

Immersed Electrode Salt Bath Furnace



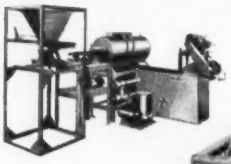
Electric Car-Bottom Furnace



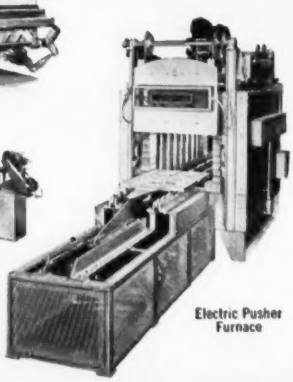
Electric Draw Furnace

Gas-Fired Endothermic Gas Generator

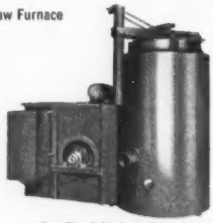
Gas-Fired Salt Pot Furnace



Electric Shaker Hearth Furnace

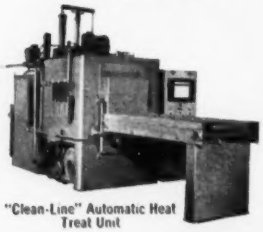


Electric Pusher Furnace

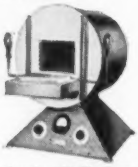


Gas-Fired Airdraw Furnace

Electric Vertical Retort Furnace

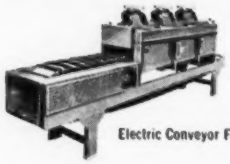


"Clean-Line" Automatic Heat Treat Unit

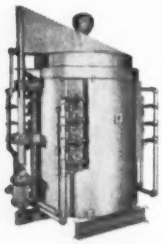


Laboratory Muffle Furnace

Combustion Tube Furnace



Electric Conveyor Furnace



Gas-Fired Pit Furnace

What's going on at

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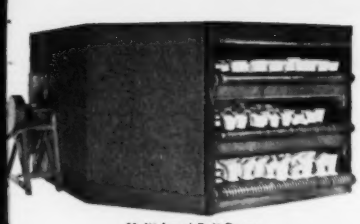
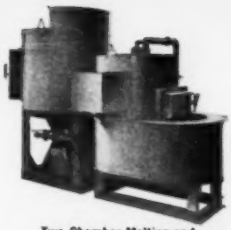
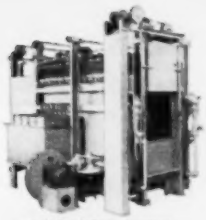


Multi-Level Belt Dryer

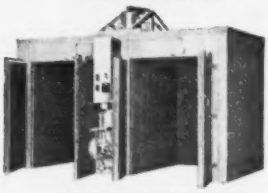
Monorail Conveyor Oven



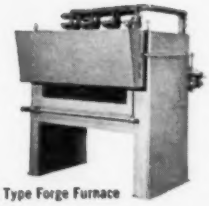
Two-Chamber Melting and Holding Furnace



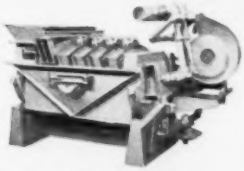
Fuel-Fired Reverberatory Furnace



Two-Chamber, Rack-Loaded Oven



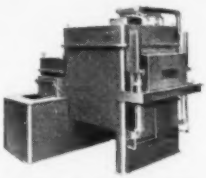
Slot Type Forge Furnace



Cradle-Type Melting Furnace

Reverberatory Aluminum Melting Furnace

Gas-Fired Tray Loaded Oven



Double Chamber Dry Hearth Melting and Holding Furnace

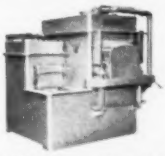
Magnesium Melting and Holding Furnace

Gas-Fired Barrel Melting Furnace

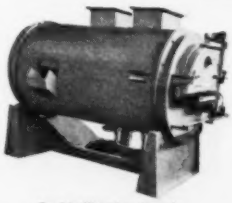
Electric Resistance Holding Furnace

Electric Tray Loaded Oven

Iron Pot Melting Furnace

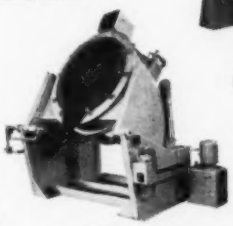


Double Chamber Aluminum Melting and Holding Furnace



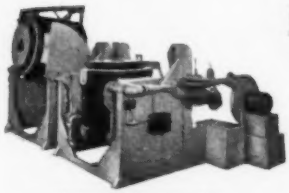
Double Chamber Barrel Furnace

Stationary Crucible Melting Furnace



Hydraulic Tilt Iron Pot Furnace

Electric Crucible Holding Furnace



Mechanically Tilted Crucible Melting Furnace

Gas-Fired Crucible Melting and Holding Furnace

It was planned for years . . . a big, brand new plant with the latest production facilities . . . the acquisition of several heating equipment companies . . . and suddenly, Hevi-Duty offers the largest, most complete line of electric and fuel fired furnaces and ovens in the industry. Shown here are representative units available.

Write for complete details. Perhaps that expensive "custom-built model" you need is a standard item or a simple adaptation from the *big* Hevi-Duty line.

HEVI-DUTY

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NEWS TO HEAT TREATERS...

JET COOLING FOR CONTINUOUS ANNEALING FURNACES

(See Front Cover)

Jet cooling, a major innovation in annealing furnace design, developed by the General Electric Company's Industrial Heating Department, Shelbyville, Indiana, now is said to permit increased furnace output, and as much as 30 per cent reduction in floor space required by the annealing section of a typical continuous cleaning and annealing line.

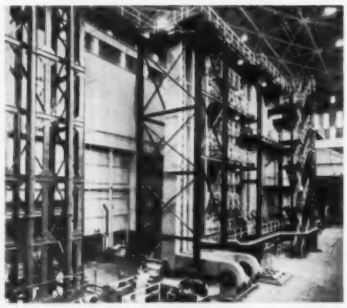
This design for faster cooling of light-gage strip employs a number of self-contained, independent units, each with its own 60-cycle, motor-driven blower and heat exchanger. These units force high-velocity cooled gases against, and perpendicular to, each strip surface.

Each of the jet units is readily accessible, providing for simple maintenance and for flexibility of operation. When furnace is designed for additional capacity in the future, cooling facilities may be extended easily by the installation of additional jet units and rolls.

The commercial feasibility and operating performance of the new system is being demonstrated by a General Electric tower-type jet-cooled annealing furnace installed at the Wheeling Steel Corporation Plant in Yorkville, Ohio. The new furnace, in production since May 11, 1959, is the first of its kind installed in a tinplate mill anywhere in the world.

Pioneers in using the new jet cooling system, Wheeling Steel placed the furnace on their 360-foot-long, $6 million continuous cleaning and annealing production line. During normal operation, there is approximately 3,100 feet of strip in process from payoff reel to recoiler.

According to Mr. A. B. Chamberlin, Annealing Superintendent at Wheeling Steel's Yorkville Works, "the new furnace has cut production time from approximately 120 hours by the old batch annealing system to less than one-half hour. The new eight-pass jet cooling system, as contrasted to a 30- to 36-pass conventional water-wall system, reduced the over-all cost of the installation (particulary building costs) and permits us to maintain good temperature control at speeds ranging from 500 to 1,200 f.p.m."



According to General Electric Company engineers, the primary feature of this major breakthrough in furnace design is the marked increase in heat transfer now possible. This increase permits cooling to temperatures lower than any other known dry cooling methods.

Jet cooling is effective in the temperature range of 900°F to 100°F for furnaces operating with strip speeds up to 2,000 feet per minute at outputs up to 60 tons per hour. Eight passes of strip in the cooling portion of a new tower-type annealing furnace can now accomplish the cooling that 30 passes produce with conventional "cool room" or water-wall designs.

For further information circle No. 11

MTI ANNUAL MEETING

The Metal Treating Institute held its 46th consecutive meeting in Chicago, Illinois, at the Sheraton-Towers Hotel on November 5, 6, and 7. One of the outstanding features of the three-day meeting was the participation by the members of the Institute in the Joint MTI-ASM Heat Treating Session which was part of the 41st National Metal Exposition and Congress.

This joint ASM-MTI technical session was held at the Hotel Sherman on Thursday morning, November 5, in the Grand Ballroom, and the following members of the MTI presented these papers:

"Carbon Control During Heat Treatment" by Robert W. Krogh of Ipsenlab of Rockford, Rockford, Illinois; and

"Heat Treating Specifications—a Few Weak Spots" by Lou J. Haga, State Heat Treat, Inc., Grand Rapids, Michigan.

These two individual papers were followed by a panel discussion which was led by K. U. Jenks, Lindberg Steel Treating Company, Melrose Park, Illinois. He served as Chairman and Moderator. Members of the panel and their subjects were:

"Heat Treatment of Gears" . . .
". . . by Furnace and Induction" by N. O. Kates of Lindberg Steel Treating Company, Melrose Park, Illinois;
". . . by Flame" by J. T. Howat, Pittsburgh Metal Processing Company, Inc., Pittsburgh, Pennsylvania;
". . . by Nitriding" by Horace C. Knerr, Metlab Company, Philadelphia, Pennsylvania; and
". . . by Salt Bath" by M. Soviak, Commercial Steel Treating Corp., Detroit, Michigan.

The second day of the meeting featured two speakers; I. Austin Kelly III, President, National Employee Relation Institute, Inc. spoke on the subject "Keeping More of the Money You Make," a discussion of pension and profit-sharing programs for small businesses; and the second speaker was Mr. Robert S. Day of Leeds and Northrup Company, Philadelphia, Pennsylvania, who spoke on the subject "Accuracy and Reproducibility in Select-

(*Continued on page* 30)

Don't throw away quenching rejects!

A recent job order for 45,000 automotive head bolts resulted in variable core hardness after quenching. Recharging the system with Sinclair Quenchol® 521 brought the bolts to uniform hardness of 52-54 Rc—and the 45,000 bolts were saved! Quenchol oils have earned the reputation for long service life, too—a further saving. Next time management asks you how you've cut costs, tell them you've switched to Sinclair—and show them far superior results in quenching.

Call your **Sinclair Representative** for further information, or write for free literature to Sinclair Refining Company, Technical Service Division, 600 Fifth Avenue, New York 20, N. Y. There's no obligation.

Sinclair

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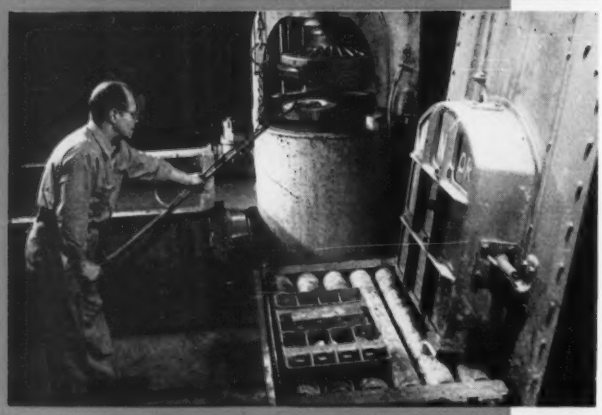
Quenching Oils

For further information circle No. 12

Bear in mind—it takes SKILL and EXPERIENCE to Heat Treat Metals . . . Your Commercial Heat Treater provides BOTH



It takes more than equipment, no matter how modern, to perform the complex heat treating processes required today to achieve the property specifications of many metals.

Without the proper combination of operational skill and technical knowledge developed by years of experience, even the most mechanical, up to date equipment can become a menace to your product and a destroyer of your business.

Today the commercial heat treating industry has definitely established its position as the source of skilled, experienced heat treating for all types of metals. Whatever your heat treating problem, always consult your commercial heat treater FIRST.

HEAT TREATING—SHOULD YOU DO IT YOURSELF?

MTI
MASTER CRAFTSMEN
METAL TREATING INSTITUTE

Write for the booklet "Heat Treating—Should You Do It Yourself"

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Southern Metal Treating Co., Inc.
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CALIFORNIA

Certified Steel Treating Co.
2454 E. 58th St., Los Angeles 58
Lindberg Steel Treating Co.
2910 S. Sunol Drive, Los Angeles 23
Cook Induction Heating Co.
4925 East Slauson Ave., Maywood

CONNECTICUT

Commercial Metal Treating, Inc.
89 Island Brook Ave., Bridgeport 6
Stanley P. Rockwell Co.
296 Homestead Ave., Hartford 12
Ireland Heat Treating Co.
512 Boston Post Road, Orange

ILLINOIS

Accurate Steel Treating Co.
2226 W. Hubbard St., Chicago 12
Allied Metal Treating Corp. of Illinois
333 N. California Ave., Chicago 12
Dura-Hard Steel Treating Co.
2112 W. Rice Street, Chicago 22
Perfection Tool & Metal Heat Treating Co.
1756 West Hubbard St., Chicago 22
Fred A. Snow Co.
1942 West Kinzie St., Chicago 22
American Steel Treating Co.
P. O. Box 396, Crystal Lake
Lindberg Steel Treating Co.
1975 N. Ruby St., Melrose Park
Eklund Metal Treating, Inc.
721 Beacon St., Rockford
Scott & Son, Inc.
1510 First Ave., Rock Island
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2125 Kishwaukee Street, Rockford
O. T. Muehlemeyer Heat Treating Co.
1500 Preston St., Rockford

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1630 Locust Street, Anderson

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Kinetics Corporation
2 Churchill Road, Hingham
Porter Forge & Furnace, Inc.
74 Foley St., Somerville 43
New England Metallurgical Corp.
475 Dorchester Ave., South Boston 27
Springfield Heat Treating Corp.
99 Margaret Street, Springfield
Greenman Steel Treating Co.
284 Grove St., Worcester 5

MICHIGAN

Anderson Steel Treating Co.
1033 Mt. Elliot Avenue, Detroit 7
Bosworth Steel Treating Co.
18174 West Chicago Blvd., Detroit 28
Commercial Steel Treating Corp.
6100 Tireman Ave., Detroit 4
Commonwealth Industries, Inc.
5922 Commonwealth Ave., Detroit 8
Vincent Steel Process
2424 Bellevue Ave., Detroit 7
State Heat Treat, Inc.
520 32nd Street, S. E., Grand Rapids 8
Royal Oak Heat Treat, Inc.
21419 Dequindre, Hazel Park
American Metal Processing Co.
12000 East Nine Mile Road, Warren

MINNESOTA

Metallurgical, Inc.
900 East Hennepin, Minneapolis 14

MISSOURI

Metallurgical, Inc.
1727 Manchester Ave., Kansas City 8
Lindberg Steel Treating Co.
650 East Taylor Ave., St. Louis 15
Paulo Products Co.
5711 West Park Ave., St. Louis 10

NEW JERSEY

American Metal Treatment Co.
Spring and Lafayette Sts., Elizabeth
Benedict-Miller, Inc.
Marin Ave. & Orient Way, Lyndhurst
Bennett Heat Treating Co., Inc.
246 Raymond Boulevard, Newark 5
L-R Metal Treating Corp.
107 Vesey St., Newark 5
Temperature Processing Co., Inc.
228 River Road, North Arlington

NEW YORK

Owego Heat Treat, Inc.
Rural Route 1, Apalachin
Fred Heinzelman & Sons, Inc.
138 Spring St., New York 12
Alfred Heller Heat Treating Co., Inc.
391 Pearl St., New York 38
Lindberg Steel Treating Co.
620 Buffalo Road, Rochester 11
Rochester Steel Treating Works
962 Main Street, E. Rochester 5
General Heat Treating Corporation
206 Sand Street, Syracuse 3
Syracuse Heat Treating Corp.
1223 Burnet Ave., Syracuse 3

OHIO

Queen City Steel Treating Co.
2980 Spring Grove Ave., Cincinnati 11
Ferrotherm Co.
1861 E. 65th St., Cleveland 3
Lakeside Steel Improvement Co.
5418 Lakeside Ave., Cleveland 14
George H. Porter Steel Treating Co.
1273 East 55th Street, Cleveland 3
Reliable Metallurgical Service, Inc.
3827 Lakeside Ave., Cleveland 14
Winton Heat Treating Co.
20003 Lake Road, Cleveland 16
Dayton Forging & Heat Treating Co.
2323 East First St., Dayton 3
Ohio Heat Treating Co.
1100 East Third St., Dayton 2

PENNSYLVANIA

Drever Company
Red Lion Rd. & Philmont Ave., Bethayres
Robert Wooler
Dresher
Wiedemann Machine Co.
Gulph Road, King of Prussia
J. W. Rex Co.
Eighth and Franconia Avenue, Lansdale
Lorenz & Son
1351 N. Front St., Philadelphia 22
Metlab Company
1000 E. Mermaid Lane, Philadelphia 18
Pittsburgh Commercial Heat Treating Co.
49th St., and A.V.R.R., Pittsburgh 1
Pittsburgh Metal Processing Co., Inc.
1850 Chapman Street, Pittsburgh 15

TEXAS

Dominy Heat Treating Corp.
P. O. Box 5054, Dallas
Superior Heat Treating Co., Inc.
P. O. Box 69, Fort Worth 1
United Heat Treating Company
2005 Montgomery Street, Fort Worth 7
Cook Heat Treating Co., of Texas
6233 Navigation Boulevard, Houston 11
Houston Heat Treating Company, Inc.
2100 Quitman Street, Houston 26
Lone Star Heat Treating Corp.
5212 Clinton Dr., Houston 20

WISCONSIN

Allied Metal Treating Corp.
P.O. Box 612, Milwaukee 1
Metal Treating, Inc.
720 South 16th St., Milwaukee 4
Supreme Metal Treating Co.
4440 West Mitchell St., Milwaukee 14
Thurner Heat Treating Co.
809 West National Ave., Milwaukee 4
Wisconsin Steel Treating & Blasting Co.
1114 South 41st Street, Milwaukee 15
Harris Metals Treating Co.
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CANADA

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27 Bermondsey Road, Toronto 16, Ont.

All of the above listed firms are members of the

METAL TREATING INSTITUTE

271 North Avenue, New Rochelle, N. Y.

NEWS TO HEAT TREATERS

(*Continued from page* 26)

ing the Right Temperature Control System."

Friday evening featured the Annual Reception Banquet and Floor Show with dancing in the Tally-Ho Room of the Sheraton-Towers Hotel.

I. Austin Kelly III, President of the National Employee Relation Institute, Inc., (left) is shown here with President of the MTI K. U. Jenks of Lindberg Steel Treating Co., Melrose Park, Ill., following his talk presented to the MTI Annual Fall Meeting.

President K. U. Jenks (left) congratulating Robert S. Day of Leeds & Northrup Company, Philadelphia, upon completion of his address before the Annual Meeting of the Institute.

The concluding meeting on Saturday morning included the Business Meeting and election of new members of the Board of Trustees and Officers.

The following members were elected officers of the MTI for 1959-60:

President
C. Robert Weir
Commonwealth Industries, Inc., Detroit, Michigan

Vice President
John H. Ries
Lakeside Steel Improvement Company, Cleveland, Ohio

Treasurer
Lloyd G. Field
Greenman Steel Treating Company
Worcester, Massachusetts

Three new members of the Board of Trustees were elected for two-year terms:

Charles F. Dominy
Superior Heat Treating Company, Inc., Fort Worth, Texas

Ben F. Rassieur
Paulo Products Company
St. Louis, Missouri

Harvey L. Miller
Benedict-Miller, Inc.
Lyndhurst, New Jersey

Past President K. U. Jenks of Lindberg Steel Treating Company, Melrose Park, Illinois, is a member of the Board *ex-officio*.

In addition, two new Board members were elected for one-year terms:

John C. Paterson
Commercial Steel Treating Corporation
Detroit, Michigan

Robert W. Fish
Lindberg Steel Treating Company
Los Angeles, California

The following member of the Board of Trustees is serving the second year of his two-year term:

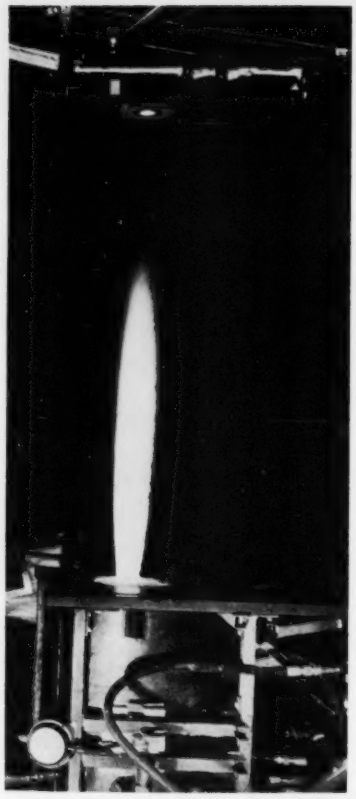
Elmer J. Cox
Pittsburgh Commercial Heat Treating Company
Pittsburgh, Pennsylvania

JET BURNER

A "miniaturized" method for testing the resistance of missile components and materials to the increasing high heat of aerodynamic friction was recently devised for a top missile manufacturer who desired an easy, efficient, and economical method.

Engineers at Selas Corporation of America, Dresher, Pa., created a new gas-air burner which produces 6 million B.T.U. per hour at 3000°F and a velocity of 2000 fps . . . produces a rate of energy/release in excess of 2000 hp.

In laboratory tests using this burner the rapidly varying heat flux curve, supplied by the manufacturer, was simulated with precision by moving the target, on a closely programmed time schedule, towards



the blast of the burner. Photo shows a calorimeter plate beginning to glow from the effects of the flame as the servo-positioned car moves it forward. Sound level of the roaring flame is 115 decibels at 50′.

For further information circle No. 14

DUAL-OUTPUT INDUCTION HEATER

Work coils can now be brought to the work up to a distance of 50 feet away from the generator with a new, remote-operated, dual-output induction heater just introduced by Induction Heating Corp. of Brooklyn, N. Y. The new portable unit can be applied to almost any job and makes it possible to bring the work coils to the work, in contrast to conventional procedures where the work has to be brought to the work coil.

The first units were especially designed for, and currently are in full-scale production service at major aircraft manufacturers, brazing fuel and hydraulic lines and fittings inside the body of a plane. The in-

(Continued on page 32)

C. I. HAYES SELLS MORE THAN JUST HEAT TREATING EQUIPMENT
. . . WE SELL LONG-TERM CUSTOMER SATISFACTION – WITH THE

5-point Results Guaranteed plan!

1 DETERMINE BEST PROCEDURE . . .

The Hayes Laboratory is unique . . . it allows you to take an active part . . . see the actual results . . . of procedures and operations developed to suit your specific needs. Hayes laboratory facilities . . . and the services of our entire staff . . . are available during this vital phase . . . WITHOUT COST OR OBLIGATION. Step 1 to RESULTS GUARANTEED!

2 SELECT RIGHT EQUIPMENT . . .

Your customized procedures are developed on an extensive line of full-scale *production* heat treating equipment . . . not laboratory models. The equipment that goes into your plant is identical to that you *actually saw* meet your requirements. If models of proper size are not available, equipment will be tailored to your exact needs. Step 2 to RESULTS GUARANTEED!

3 START-UP AND INSTRUCTIONS

Free start-up service by a Hayes engineer completely familiar with the procedure developed assures duplication of laboratory results. Your staff is fully instructed on how to make the operation most economical and how to maintain the equipment for maximum life. Step 3 to RESULTS GUARANTEED!

4 PROPER SERVICING . . .

Hayes is known for its prompt, competent service . . . well aware that heat treating equipment is production equipment and that downtime is costly to the customer. Hayes maintains a private plane that speeds its Service Engineers to you when needed. Hayes is just as concerned about your equipment *after* you buy it as *before* you buy it. Step 4 to RESULTS GUARANTEED!

5 MAINTAINING OPTIMUM OPERATION . . .

Hayes maintains an extensive inventory of stock parts . . . your assurance that the equipment can be maintained in optimum operating condition long after competitive equipment has become obsolete or worn out. Because highest quality materials are used, less frequent rebuilds are required. Relatively few Hayes furnaces appear on the used-furnace market . . . proof that customers buy 'em, like 'em, hang on to 'em! Step 5 to RESULTS GUARANTEED!

Solve your heat treating problems the RESULTS GUARANTEED way! Request bulletins for complete data on any of the famous C. I. Hayes CERTAIN CURTAIN electric furnace line.

ELECTRIC CERTAIN CURTAIN FURNACES

FREE LITERATURE: Please send data on equipment for procedures checked.

- ☐ High Speed Hardening
- ☐ Tool Steel Hardening
- ☐ Carbo-Nitriding
- ☐ Tempering
- ☐ Vacuum Heat Treating
- ☐ Bright Heat Treating
- ☐ Stainless Steel Heat Treating
- ☐ Sintering
- ☐ Copper Brazing and Soldering
- ☐ Lead Pot Hardening and Tempering
- ☐ Atmosphere Generation
- ☐ Gas Drying
- ☐ Other

C. I. HAYES, INC.

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Name.....*Title*.....

Company.....

Street.....

City.....*State*.....

For further information circle No. 15

NEWS TO HEAT TREATERS

(*Continued from page* 30)

duction unit and its accessory equipment are shock-mounted on a rugged, mobile platform, and can be towed to its place of operation at speeds up to 15 mph.

The Ther-Monic unit comes complete with dual output station and required controls for accessory equipment and each remote station. Two flexible, low-loss, high-frequency coaxial cables furnish power

to *two* work coils in different parts of the plane—performing alternately, each handled by its own operator. When the brazing operations in various sections of the plane are completed, the gear is readily moved on to do its work in the next plane on the production line. Only the input power cable must be disconnected before moving the entire unit.

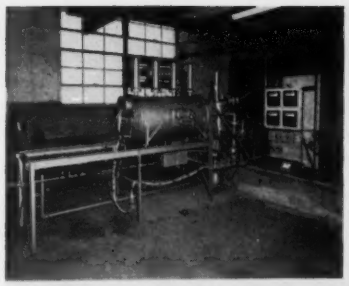
For further information circle No. 16

BRAZING STAINLESS STEEL HONEYCOMB

Grumman Aircraft Engineering Corporation, Bethpage, N. Y., has ordered from F. J. Stokes Corporation, Philadelphia, Pa., equipment for the production-scale brazing of honeycomb structures under vacuum.

The equipment will be capable of brazing panels in excess of 50 square feet in area. It will be used for fabricating structures for the "Eagle" air-to-air missile, a recently-disclosed project being developed by the U. S. Navy's Bureau of Aeronautics.

Grumman will be the first in the aircraft and missile manufacturing



industry to utilize on a production-scale the Stokes-Bukata vacuum brazing process for honeycomb structures. The process utilizes a wholly new procedure, avoiding the need for making expensive and time-consuming welded "envelopes" to enclose the work. This permits the panels to be rapidly loaded and unloaded. The extremely high-vacuum atmosphere created in the equipment also eliminates the need for costly inert gas.

Advantages of vacuum in place of inert gas in brazing honeycomb structures were explained by Stokes Vacuum Metallurgical Department. Preliminary work has also demonstrated that the new process offers additional benefits through the combination of elevated temperatures and high vacuum to remove many residual surface contaminants through evaporation.

The pilot-scale prototype equipment (shown in the accompanying photos) has already been proven and is currently in regular operation in the Stokes Laboratory. Qualification panels (1′ x 2′) brazed in the pilot-scale equipment are being tested by aircraft manufacturers.

The equipment initially will operate at 1750°F, high enough for all present honeycomb work, and can be operated successfully at temperatures in excess of 2100° F.

The unit incorporates provision for cooling of the work once the brazing material has fused, especially desirable with precipitation-hardening type honeycomb materials such as 15-7 Mo. and 17-7 PH stainless steels.

Both Stokes and the process inventor, Stephen Bukata, consultant on honeycomb brazing, express optimism for this approach on newer honeycomb materials such as titanium, molybdenum and beryllium, where the oxygen sensitivity is even greater.

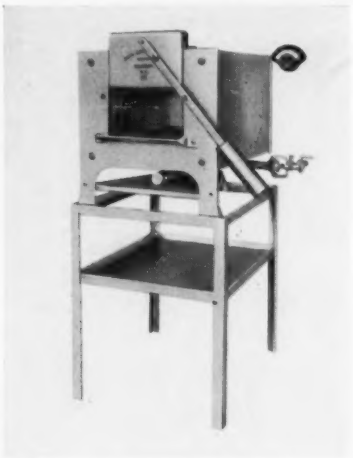
For further information circle No. 17

"BUZZER FURNACE"

Charles A. Hones, Inc., Baldwin, N. Y., manufacturers of self-contained "Buzzer" industrial gas furnaces and burners which operate without blower or other power, announces a number of important engineering changes in the standard Bench-Type Oven Furnace.

A new cast iron venturi burner with modernized port design, replacing the previous machined steel burner, takes reflected heat better to speed up metal working, and a new hearth mix in a special silicon carbide formula exceeds previous shock limits and provides greater resistance up to 2000° F. The furnace also has integral easily-lit, reliable pilot for faster, simplified operation, and a new higher powered venturi which entrains more pri-

mary air providing higher flame temperatures, quicker combustion, and cleaner results. The unit is a quiet one because of its exclusive maintenance-free venturi burner design, with versatile applications for



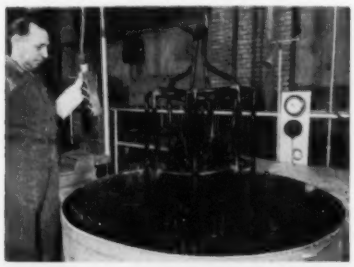
heat treating low-carbon steel, preheating high-speed steels and numerous other metalworking functions without the need for an air blower. It is available in 6 standard size models.

For further information circle No. 18

QUENCH REDUCES DISTORTION

Among the toughest jobs handled by the heat treat department of Iron Fireman Manufacturing Company, Cleveland, Ohio, are the worm shafts which drive basic components of industrial heating units.

Of AISI 5140 steel, the worm shafts are 23-1/16th ins. long and range in diameter from 1-1¾ ins.



Screw threads, neck sections, and other machined profiles create many variations in diameter which sets up the danger of "cork-screwing" in acute form.

The shafts are first hardened by heating at 1525° F in a Lindberg

(*Continued on page* 37)

NEW NEW NEW NEW NEW NEW NEW NEW NEW

WHEN IT

MELTS

you know the *temperature!*

NEW

***Markal*®**

THERMOMELT

TEMPERATURE INDICATORS

with handy adjustable holder

the easy modern way to determine exact working temperatures!

Just mark or stroke the surface with THERMOMELT . . . when it reaches the desired temperature, the mark liquefies. There's no guesswork, no wasted time or material . . . THERMOMELT is the quick, precise way to determine heating temperatures. Accurate to within ±1%.

A STIK FOR EVERY TEMPERATURE from 113°F. to 2000°F.

ALSO AVAILABLE IN LIQUIDS AND PELLETS for inaccessible or hard-to-measure applications. Wide range of temperatures.

Send today for free THERMOMELT literature and pellet sample (indicate temperature desired).

MADE BY THE MANUFACTURERS OF MARKAL PAINTSTIK MARKERS AND PROTECTIVE COATINGS

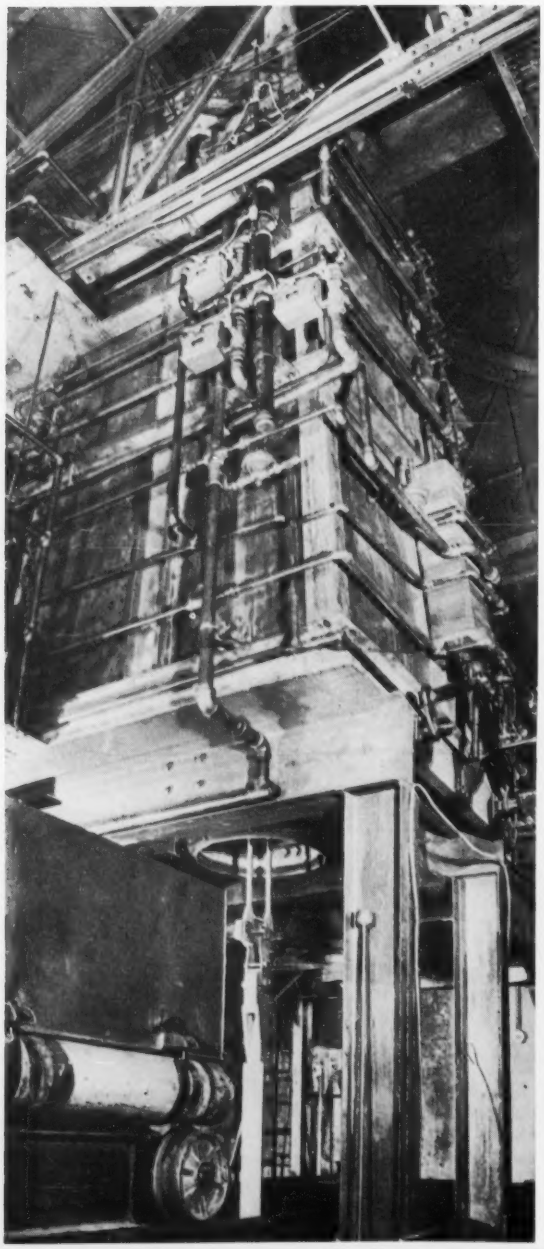
MARKAL COMPANY 3102 West Carroll Avenue, Chicago 12, Illinois

For further information circle No. 19

(Continued from page 9)

have a sealed outer shell, gas-fired furnaces, a retort or indirect radiant tube heating elements.

Having reached the correct temperature and saturation, the bottom door is opened and the work is lowered rapidly or slowly, as desired, straight down into the quench tank which has been brought into position below the furnace.



Original Design

The first furnace of the inverted pit type was designed (and patented) by the writer, built and placed in operation in 1928 at the original plant of METLAB CO. in Philadelphia.[4] Its purpose was to heat treat slender, tubular structural parts of aircraft, such as struts, engine mounts, axles, landing gear, etc. Its heating chamber was 3 ft. square by 10 ft. high. (See Fig. 2). Soon after, a second such furnace was built at the same location for the heat treatment of tubular steel wing beams, spars for autogyro and helicopter rotors, and miscellaneous alloy steel tubing. Its heating space was 2 ft. dia. by 24 ft. high. Both furnaces were electrically heated, with full automatic temperature control, divided by zones from top to bottom. Quenching was in oil.

Practically all of the long, slender delicate structural members for the aircraft industry (then located in the East and Middle West), were heat treated in these two furnaces from 1928 to 1937. Both employed quench tanks moving laterally under a stationary furnace. (See Fig. 3).

The steel used was principally 4130 X, Army-Navy Standard, of the following composition:—

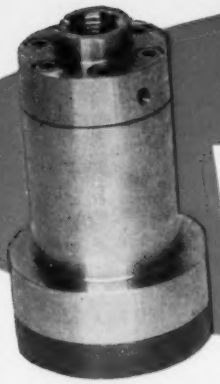
C — 0.25 — 0.35	Cr — 0.80 — 1.10
Mn — 0.40 — 0.60	Mo — 0.15 — 0.25
P max. — .040	S max. — .045

Tensile values up to 185,000 Y.P., 215,000 Ult. and even 200,000 Y.P., 240,000 Ult. were obtained when

[4] A description was published in *Iron Age*, August 29, 1929.

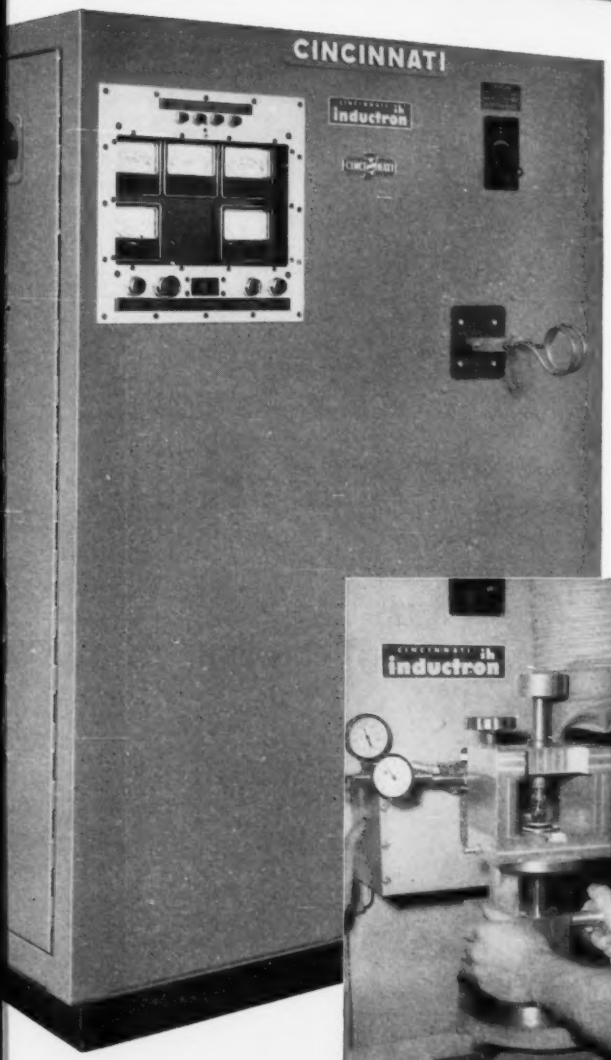
(Continued on page 36)

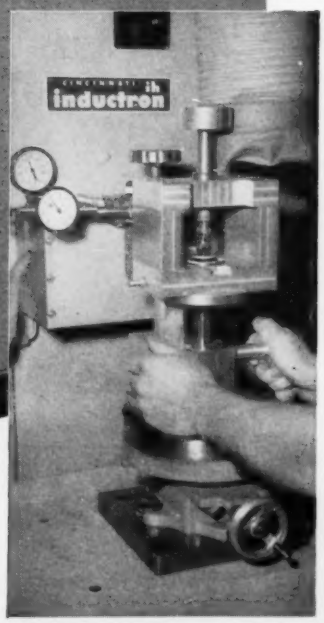
Fig. 4—New inverted pit furnace erected in 1938. Heating space 3' dia. x 13½' high. Inconel retort; any desired atmosphere. Propane fuel. Five zones of automatic control, ten point recorder (shown at right) indicates work temperature.



with just a KISS of 1000 kc's

CINCINNATI inductron® precision-brazes Statham Pressure Transducers





Photos above show Cincinnati Inductron induction heating machine and close-up of fixture used to braze 150 different sizes and styles of pressure transducers. Hose over fixture exhausts heat. One type of completely assembled Statham Pressure Transducer is shown, above, actual size.

Statham Instruments, Inc., Los Angeles, required a brazing operation before the final assembly of their extraordinarily accurate pressure transducers. These instruments record pressures ranging from fractions to thousands of psi. Among other sensitive components, the coils in these instruments are wound from wire so fine that it floats in air. To braze these transducers, the heat must be precisely located and applied . . . or a nearly complete, accurately adjusted instrument will be destroyed.

Because of its precise control of high frequency output (up to approx. 1200 kc) a Cincinnati 15 KW Inductron was the economical solution to this assembly problem. Brazing three joints is typical of the work accomplished. Using a calibrated fixture on an adjustable table for exact work positioning, the joints are quickly brought up to brazing temperature. The heat cycle for some transducers is but 0.2 second—just a kiss of 1000 kc's. With the Inductron's variable output RF transformer—rotating a dial varies the heating characteristics of the coil—only 25 different coil forms are needed to braze 150 instrument sizes and styles.

For your heat processing work, look to the Cincinnati Inductron for lowest cost induction heating . . . and to the Cincinnati Flamatic for lowest cost flame heating. Call in a Meta-Dynamics Division field engineer for full details.

inductron
flamatic
hardening machines
META-DYNAMICS DIVISION
Machines for Metal Forming and Heat Treating

THE CINCINNATI MILLING MACHINE CO.
Cincinnati 9, Ohio, U.S.A.

CINCINNATI

further information circle No. 20

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called for. For highest physical properties steel on the high side of the carbon and alloy range was selected. For still higher properties or for thickness over about ¼", the carbon was held at 0.35-0.45 (4137-4140).

A furnace employing the same principle of design but of smaller size was installed at the U. S. Naval Aircraft Factory in Philadelphia about 1932. Its tanks were mounted on a rotating carrier in a pit beneath the furnace.

Gantry Type

As described in the writer's original patent, the first inverted pit furnace was mounted stationarily and the quench tank and loading rack moved laterally beneath.

Various later designs employed the so-called "gantry" principle, wherein the furnace is mounted on wheels and travels back and forth over fixed quench tanks and loading pits beneath. This needs less pit length, but has the serious disadvantage of requiring travelling service lines, including gas fuel, if used, artificial atmosphere, electric power lines for heat and for operation and temperature control, etc. Also, it seems to the author to be doubtful engineering to roll a tall, hot furnace, built of refractory materials and carrying a delicate, suspended charge, back and forth at each operation.

Fig. 5—Typical rocket bodies heat treated in furnace shown in Fig. 4. Approximately 2' dia., 13' long overall. Body 11' long, wall 3/16" thick. Steel 4130 X. Yield point 160,000 psi min. Held to .070" TIR combined out-of-round and bow, in full length. Bodies showed up to .125" TIR before heat treatment.

Other Furnace Types—Ordinary Pit

Early rocket fabricators in this country employed an older furnace design consisting of a pit, with the cover on top. This type had been used for many years in the heat treatment of Navy guns, some being as deep as 75 feet. The rough-machined gun is suspended vertically from a heavy spider, lowered into the furnace, the spider resting on the upper rim, after which the cover is replaced. Heating is electrical or by open burners, scale being unimportant.

To quench, it is necessary to remove the cover (whereupon the furnace atmosphere escapes and cold air is drawn in), then raise the spider until the piece is clear of the rim, then move laterally over a quench tank in an adjacent pit, and lower. A heavy gun forging will retain its heat during this operation, but a thin-walled body starts to cool at the top as soon as the cover is removed, continues cooling while being raised, moved over and lowered into the quench. The lower end is exposed for a shorter time. The top is therefore considerably cooler than the bottom end when quenching is accomplished, making for non-uniform properties. Loss of furnace atmosphere upon opening the furnace and the entry of air makes it difficult or impossible to insure controlled satisfactory atmosphere during heat treating. Both scale and decarburization may result. Air hardening steels can be satisfactorily treated in this type of furnace although atmosphere regulation is difficult.

Salt Pot Furnace

In an effort to maintain "neutral" conditions, avoid scale and improve temperature uniformity within the heating space, molten salt baths have been used. By convection, the salt bath tends toward temperature uniformity. The film of salt adhering to the work protects surfaces from oxidation during transfer to the quench bath; but the transfer time, with a resulting cooler top, is still the same as in a pit furnace.

Salt baths as a heating medium have advantages and are indispensable for many types of heat treating. But they have grave disadvantages for rocket bodies, and in the writer's opinion should be prohibited. During use they are inclined to become contaminated or otherwise deteriorate so that they are no longer neutral and tend to decarburize or even pit the steel surfaces. Perhaps even more dangerous, because harder to guard against, is the fact that molten salts penetrate even the most minute crevices, including fayed surfaces, over-

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NEWS TO HEAT TREATERS

(Continued from page 33)

electric furnace and quenching to 45-46 Rockwell C., and then reheated at 950-1000° F for one hour to cut hardness back to the specified 35-39 Rockwell C.

The shafts are then quenched in a circulating overflow quench bath. Temperature of the quenching medium—an oil which combines high initial quenching speed with slow cooling in the distortion range—is held to an average of 180 F. A clock and thermometer installed on the bath assist in quench control. The shafts must be held to a maximum of .030 in. out of straightness.

With the use of Gulf Super-Quench, Iron Fireman betters this maximum distortion allowance by one-third—for an average distortion of only .020 in. per shaft quenched in bulk lots. The reduced distortion is achieved as a result of the slow cooling effected by Gulf Super-Quench in the final stage of quench. Its initial high quenching speed through the hardening range assures deeper and more uniform hardening even for parts with the variable sections typical in worm shafts.

For further information circle No. 21

HEAT TREATMENT OF STEEL

A 40-page, illustrated booklet with charts, micrographs, and photographs has been published by The Sandvik Steel Works Co., Ltd., Sweden entitled *Steel: Structure and Heat Treatment.*

The booklet contains, first a short theoretical outline of the effects of heat treatment on the microstructure of steels and, secondly, some practical advice on the usual heat treatment processes. It also contains an index to simplify the identification of technical terms and process descriptions.

The mechanical properties of a steel depend largely on the heat treatment to which it has been subjected and on the structure which it has acquired as a result. This book-

For further information circle No. 22

(Continued on page 43)

2 IMPORTANT NEW VACUUM FURNACES BY Kinney®

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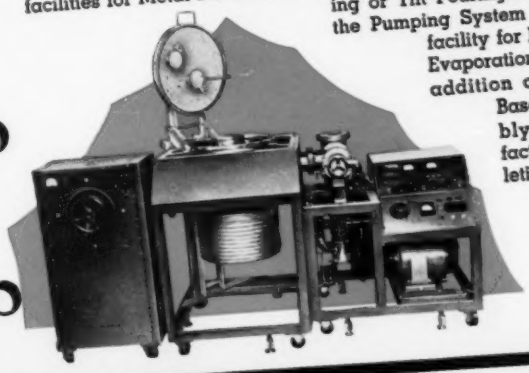

COMPLETE YOUR FILE OF CURRENT INFORMATION ON DEVELOPMENTS IN HIGH VACUUM EQUIPMENT FOR METALLURGISTS

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For further information circle No. 23

(Continued from page 36)

laps in welds, weld cracks, if any, and even tiny surface laps and seams in the sheet. It is almost impossible to assure complete removal of salt traces after heat treating. These salts contain chlorides, are hydroscopic and may, in time, cause corrosion pits on the inside of bodies where they cannot be detected. The resulting danger in rocket bodies, subject to extreme hydrostatic pressure in service, is obvious.

Flame or Induction Hardening

Under the name "Progressive Heat Treatment" an ingenious method was tried whereby an acetylene flame and water quenching jet were moved along a rotating body, to harden it. Serious practical difficulties were encountered, including the risk of local cracks or soft areas fatal in rockets, and the method was abandoned.

Induction hardening has been employed on some smaller bodies. Again, technical difficulties, such as variation of thickness at ends, militate against the method.

Final Choice

Wisdom therefore has directed the use of the inverted pit furnace, with controlled artificial atmosphere. In addition to vertical sag-free suspension during the heating cycle, regulated and uniform heating free from surface attack by scale or decarburization can be assured.

By lowering directly out of the bottom of the furnace into the quench tank, the quenching time is controllable and can be held at a minimum (a few seconds if desired). Every portion of the body, from end to end, has the same time of exposure from heat to quench. The quenching medium can be made to circulate uniformly and at a desired rate over the metal surface. Maximum physical properties are obtained.

Rocket Steels

Many exotic alloys of special composition have been presented for the construction of bodies, with inherent or claimed superior or specialized properties. Some are hardened by "aging" (precipitation), thus avoiding a quench. These alloys are often associated with unfavorable characteristics which detract from their ultimate value; such as, difficulties of fabrication, forming, welding, weakening under elevated temperature, low modulus of elasticity, and tendency to brittleness.

Stainless steels of the type 18% chromium, 8% nickel, series 300, are capable of being cold rolled in thin sheet or strip to very high tensile properties. By fabricating these with the aid of electric resistance methods so as not to create areas of weakness, bodies of excellent lightness and strength have been produced. The method is rather specialized.

Due in part to the problem of deformation in liquid quenching, various types of air-hardening steels (even "tool" steels) have been proposed and to some extent used. Simplification of heat treatment is usually more than offset by complications encountered in fabricating, forming and welding these recalcitrant metals. The danger of welding cracks may be increased. The best combination of physical properties and fabricating qualities is still usually found in the established and available alloys of the type 4130, 4140 and 4340, and sometimes of modified composition. The combination of skill, experience and suitable equipment will achieve the desired results as to strength (lightness) and dimensional accuracy with these more common and readily available alloys, when properly selected, even at very high strength values. For example:—

A standard 4340 steel, oil quenched, will develop the following excellent properties:— 210,000 Y.P., 250,000 Ult., 6% El. in 2". SWF (YP)—27. Rockwell C 49-51. Chemistry—

C — .38 — .43	Cr — .70 — .90
Mn — .60 — .90	Mo — .20 — .30
Ni — 1.65 — 2.00	

A steel widely adopted in rocket body manufacture known as AMS 6434 Modified (Society of Automotive Engineers, Aeronautical Material Specifications), has a composition similar to standard 4340 above mentioned, with an increase in molybdenum and the addition of vanadium, but it is also under strict specifications for quality—an important point. The special molybdenum and vanadium content help in heat treating by permitting some natural cooling in air (as much as 60 seconds) before the quench. This sometimes simplifies heat treatment and helps to reduce deformation.

Composition and available tensile properties are as follows:— 220,000 Y.P., 250,000 Ult., 6% El. in 2". Rockwell C 48-50. SWF (YP)—28. Chemistry—

C — .35 — .40	Cr — .65 — .90
Mn — .60 — .80	Mo — .30 — .40
Ni — 1.65 — 2.00	Va — .17 — .23

This steel is well adapted to fabricating operations,—rolling, forming, deep drawing, welding, etc.

Where heavier sections, such as forgings, are welded to ends for head or nozzle, the steel should ordinarily be of the same type analysis as that of the shell but the carbon content should be somewhat increased (.05 to 0.10%) to compensate for mass effect in quenching and assure strength values comparable with the thinner shell.

Quality Control Essential

"Quality" in steels for rockets is of paramount importance if the heat treater is expected to meet exacting requirements. Non-uniform composition, surface decarburization, segregation, coarse grained steel, seams, inclusions and other inherent defects arising in the manufacture of the steel and the rolling and annealing of the sheet must be rigidly guarded against by suitable specifications in purchase and adequate acceptance tests. (Aircraft specifications). Neglect of these obvious precautions has resulted in untold problems in rocket manufacture, usually developing in the heat

(Continued on page 44)

INCOLOY baskets...4000 carburizing hours behind them, thousands more ahead

Resistance to carburization – ease of fabrication – great strength.

These are the three important qualities that make Incoloy* nickel-iron-chromium alloy a natural for long life in well designed carburizing baskets.

Take the experience of Mack Truck Co., Plainfield, N. J. (above). Here, stacking Incoloy baskets designed by Rolock, carry loads of clutch gears and automotive parts through carburization in pit furnaces at 1700°F.

How well do they perform? The baskets have now been in carburizing service for 4000 hours. They are still in excellent condition – have many more thousands of hours' service in them!

Long-life in carburizing service is just one advantage

Incoloy baskets deliver other important advantages, too. Light weight, they also give Mack Truck the extra bonus of faster heat-up and greater ease of handling. What's more, their fabricator is able to produce them economically because Incoloy alloy forms easily and welds readily.

If you'd like more information on Incoloy alloy for your carburizing applications, just ask. Data on Incoloy stacking baskets can be obtained from their designer and fabricator–Rolock Incorporated, Fairfield, Conn. *Inco trademark

HUNTINGTON ALLOY PRODUCTS DIVISION
The International Nickel Company, Inc.
67 Wall Street New York 5, N. Y.

INCOLOY®

(Continued from page 5)

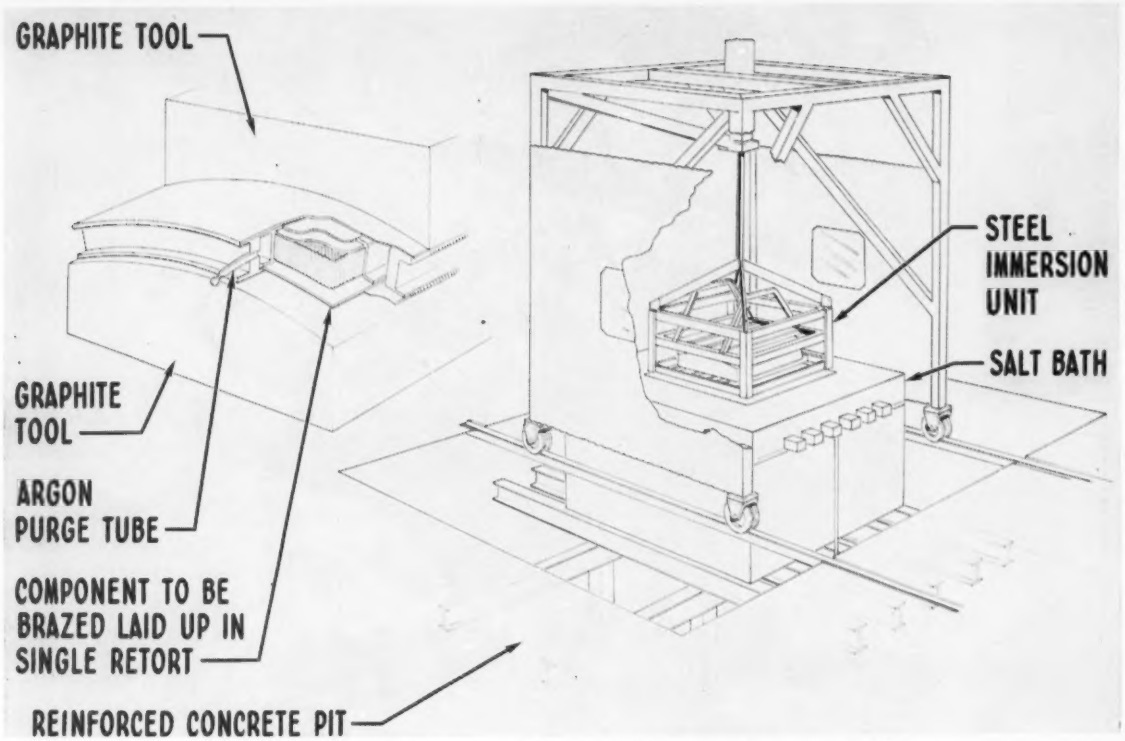


Fig. 7—Salt bath brazing in a conventional unit producing temperatures up to 1950°F

carries the loaded retort into the stabilized furnace, after which a temperature of 1625° F to 1650° F is normally attainable in 45 minutes.

After the brazing temperature is reached, the retort is taken from the furnace to a 1100-ton hydraulic press where it is placed on a water-cooled Kirksite die. When closed, the die has steel spacer bars which provide clearance for the thermal expansion of the heated retort.

No forming pressure is applied by the press, since its only purpose is to open and close dies, and brazed parts therein are cooled very rapidly.

North American engineers say die quenching is their fastest brazing process. In addition, it permits the manufacture of sandwich components with excellent mechanical properties and precision configurations. However, it incurs comparatively high tooling costs and is not suitable for the production of parts that are very large or severely contoured.

Salt bath brazing (Fig. 7) is done with a more or less conventional unit which produces temperatures up to 1950° F. Components to be brazed are in each instance laid up in a single retort, which is subsequently placed between graphite form blocks. Because they will undergo no deterioration in molten salt, the graphite blocks are directly immersed in the bath.

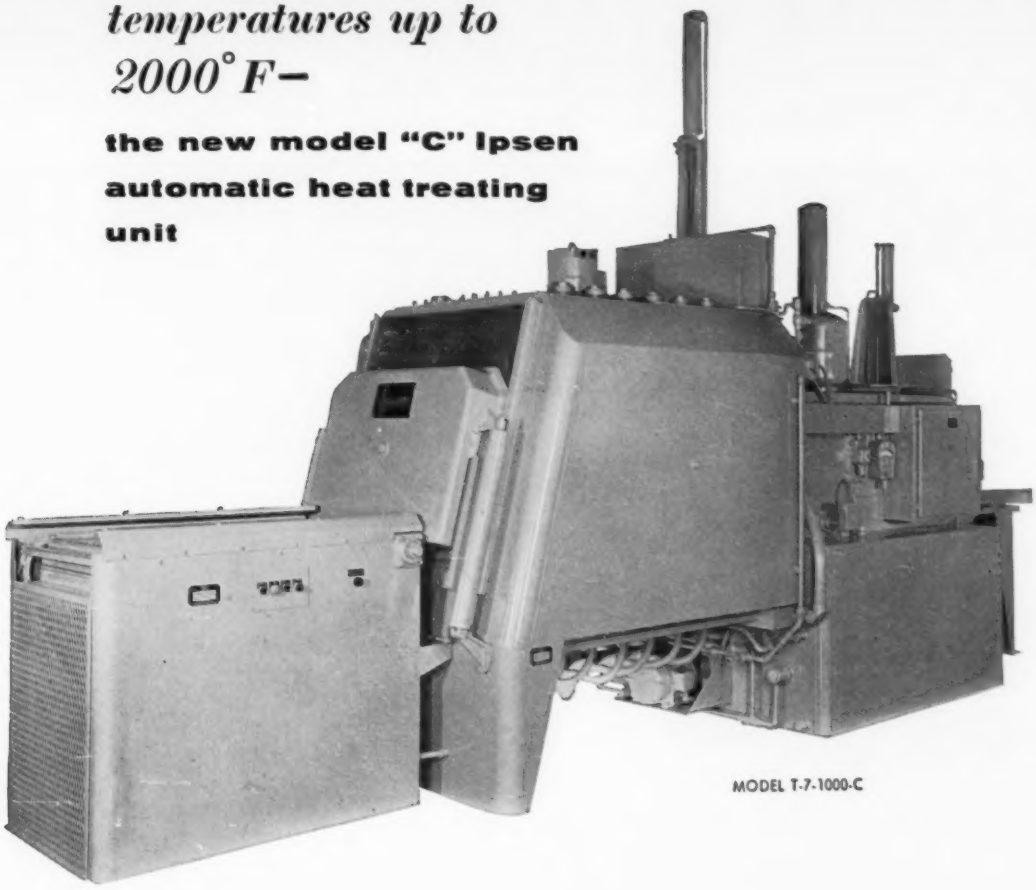
Resultant heating action is very fast and uniform, being especially suitable for the brazing of parts with massive inserts. However, the process has the disadvantage of being somewhat hazardous—since moisture trapped within a retort could cause an explosion at elevated temperatures.

To assure the close control of transformation growth in brazed sandwich structures, North American is using a liquid trichlorethylene-carbon dioxide refrigeration setup with which temperatures can be reduced to -110° F. In this unit, brazed components are retained by retorts under minimal pressures in order to maintain intimate contact between the parts and graphite reference bases; the shortest refrigeration cycle is three hours.

The company also employs precipitation hardening treatments in processing brazed sandwich structures. These treatments are carried out in conventional furnaces with parts under vacuum in their respective retorts, and time requirements are varied in accordance with differing circumstances. For example, where a brazed component has been cooled down to 1000° F in five minutes, aging may be done for one hour at 950° F; or, where a part has been cooled to 1000° F in 45 minutes, aging for eight hours at 900° F is specified. • • •

For operation at temperatures up to 2000° F—

the new model "C" Ipsen automatic heat treating unit



MODEL T-7-1000-C

This is the new Ipsen automatic heat treating unit . . . designed for carburizing, carbon restoration, carbonitriding, neutral hardening, marquenching, normalizing, annealing, and brazing. Thousands of hours of continuous operation at 2000°F prove these units can easily withstand extremely high temperatures . . . as well as carbon-rich atmospheres.

The ability to operate continuously at elevated temperatures increases production and lowers costs. For example, raising carburizing temperature from 1700°F to 1900°F doubles the case depth obtained in 3 hours. The following table shows in greater detail how higher carburizing temperatures result in increased carbon penetration:

TOTAL CASE DEPTH FOR CARBURIZING C8620 STEEL

Temperature	1 hour	2 hours	3 hours
1700°F	.023	.031	.039
1800°F	.028	.042	.055
1900°F	.038	.060	.078
2000°F	.052	.081	.104

A newly published bulletin (T-19-C) discusses, in detail, patented Ipsen features and engineering advancements such as:

- "Straight-through" design which eliminates in-and-out operation and needless loading delays or extra handling.
- Automatic loaders and in-line transfer mechanisms (which require floor space only 6" longer than actual work baskets).
- Guaranteed super-alloyed ceramic heating tubes which are impervious to high carbon and high hydrogen atmospheres . . . resist extreme temperatures of heating and cooling.
- Patented super-alloyed ceramic "Flame-Busters" which increase heating efficiency over older model furnaces by 40%.
- Ceramic fans of one piece, super-alloyed construction which can be used at temperatures beyond 2000°F.

Call your nearest Ipsen office for a copy of Bulletin T-19-C, "The facts on new Ipsen automatic heat treating units"

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For further information circle No. 25

LETTERS TO THE EDITOR

Gentlemen:

We are a contract tool and die shop and as such we do have a small heat treating department. In so far as this department is not kept one hundred per cent busy with our own work, we take in heat treating work from similar shops in our locality.

We recently came across an issue of "Metal Treating". I would like to have our name added to your mailing list to receive this publication regularly. I believe we can gather many tips and ideas from the magazine. If there is a charge for a subscription, please bill us.

Richard T. Benger
Prospect Tool and Die Company
Waltham, Mass.

Dear Sirs:

After reading your latest issue of *Metal Treating*, I would appreciate receiving information pertaining to a subscription and to the additional literature which you indicated is available upon request.

I would also like to obtain a copy of the July-August issue of *Metal Treating* for my personal use. Would you please bill me later for this issue.

H. J. Harding
Atlas Steels Limited,
Welland, Ontario,

Gentlemen:

I have just finished reading an issue of "Metal Treating" and appreciate it very much. Being directly connected with the installation and operation of our heat treating equipment, I would like to be placed on your regular mailing list for future issues.

Willard S. Smith, Jr.
Plant Equipment Engineer
Diamond Chain Co., Inc.
Indianapolis, Ind.

Dear Editor:

I am concerned with the heat treatment of missile cases and missile hardware and would certainly appreciate receiving further copies of your magazine entitled, "Metal Treating".

Thank you in advance.

Paul A. Williams
Metallurgical Engineer
The M. W. Kellogg Company
Jersey City, N. J.

Gentlemen:

We are very much interested in your article on vacuum heat treating in the September-October, 1958 issue of *Metal Treating*.

We would like to obtain approximately six (6) additional copies of this article if they are available.

D. A. Miller
Sales Manager
Trent, Inc.
Philadelphia, Pa.

Dear Sir:

I have had the opportunity to read a recent issue of "Metal Treating". Enjoyed it very much and found it very informative. Would you please add my name to your mailing list.

J. V. Muckley
Supervisor,
Plating & Heat Treating Dept.
The Hoover Company
North Canton, Ohio

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FABRICATED HEAT AND CORROSION RESISTANT ALLOYS

why they are calling us "THE MUFFLE PEOPLE"

In many years, there have been few occasions when Rolock engineers and constructors were not working on muffles . . . of almost every size and type . . . from "little fellows" to real giants. Today, this background of experience brings us many of the most important jobs in the field, some examples of which are shown above. Among many important design contributions we have made is an entirely new type of Rolock corrugated wall and roof construction that greatly extends muffle life expectancy. To a number of muffle users Rolock's experts are, indeed, the "muffle people." Building such muffles is a job that requires experienced engineering design as well as exceptional skills and craftsmanship in handling special alloy fabrication. Rolock offers you both these essentials. A constantly growing file of successful case histories shows important long-range savings to the muffle user. Let us quote on your next job . . . whether it's a standard replacement or one presenting problems to be solved.

SPECIAL SERVICE to users of Endothermic Gas Generators

Rolock maintains a prompt repair and replacement service for these gas generator retorts. Our New, improved welded-fabricated Inconel retorts out perform original equipment; offer substantial savings. **FAST DELIVERY.** We stock heads, pipes, mesh, catalyst and shell material for immediate service on a full range of large and small sizes. Write or wire.

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JOB-ENGINEERED for better work
Easier Operation, Lower Cost

2RL59B

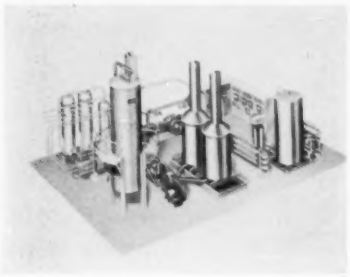
NEWS TO HEAT TREATERS

(Continued from page 37)

HYDROGEN GENERATION SYSTEM

To meet industry's increasing need for small volume, pure hydrogen, at low cost, Selas Corporation of America, Dresher, Pa., announces the availability of complete processing plants for producing up to 10,000 cubic feet per hour of high purity hydrogen.

Hydrogenation of animal and vegetable oils; production of metal hydrides, aniline and nylon; annealing ferrous and nonferrous metals; powder metallurgy and manufacture of transistors are important applications for high purity hydrogen in this low-volume range.



The Selas system—which starts with natural gas or LPG feed—incorporates a new concept in hydrogen generation and purification. Designed in capacities ranging from 1,000 to 10,000 cubic feet per hour, hydrogen purity up to 99.99% plus is possible.

The basic system delivers hydrogen at –100° F dewpoint, with carbon monoxide and carbon dioxide concentrations of less than 10 ppm and residual methane of less than 0.01%. The ultimate purity possible for the basic system is governed entirely by inerts content of the feedstock, which passes through unchanged. With 2% nitrogen in the feed, for example, the final product will contain about 0.5% nitrogen.

Operating costs, where only 99.5+ purity is required, range from 8.6¢ per 100 SCF of hydrogen, varying according to plant location.

For further information circle No. 60

HIGH VACUUM FURNACE

For heat-treating the high alloy steels used in the production of the Atlas intercontinental ballistic missile for the U. S. Air Force, which must be processed under high vacuum conditions, Convair Astronautics Division of General Dynamics Corporation, San Diego, Calif., has just ordered from the Vacuum Equipment Division of F. J. Stokes Corporation, Philadelphia, the largest cold-wall vacuum heat-treating furnace ever to be built capable of operation at temperatures of 2150°F.

The contract, amounting to more than $250,000, calls for the design, fabrication, erection, and turn-key installation of the complete system. The furnace will have a horizontal vacuum chamber 12 feet long and approximately 9 feet in diameter, which will be evacuated to working pressures of about ½ micron. Within the chamber will be a uniform-temperature work-zone about 10 feet long and 6 feet in diameter.

For further information circle No. 28

(Continued on page 48)

PROTECT METALS
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HEAT TREATING
STRESS RELIEVING!
Markal
HEAT-PROOF
COATING
FOR HIGH TEMPERATURES
PREVENTS CORROSION
OXIDATION, CARBURIZATION
STOP SCALING,
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MARKAL "C-R" COATINGS
MARKAL "C-R" COATINGS positively protect a wide range of metals against oxidation, corrosion, scaling, gas absorption at temperatures as high as 2100° F. during heat treating, annealing, normalizing or stress relieving. Easily applied with brush or spray.
MOST TYPES REMOVED BY HOT WATER AFTER TREATING
SEND FOR COMPLETE MARKAL COATING LITERATURE . . . Technical service available on special problems. Send full details on company letterhead as to type of metal, heat range, etc.
THE MARK OF QUALITY . . . MARKAL PROTECTIVE COATINGS
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For further information circle No. 27

70 years of know-how goes into your Industrial Furnace

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If yours is a special problem, our engineering staff has been solving those for nearly three quarters of a century.

For normal, no-special-problem operations, one of our standard pretested furnaces will give you longer service, at lower over-all cost, than any other unit of its kind on the market.

Semi-Muffle Type
Heat Treating Furnace

DF9-6

DENVER FIRE CLAY COMPANY
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Please send Industrial Furnace information.

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Denver Fire Clay Company

DENVER • SALT LAKE CITY • EL PASO

For further information circle No. 29

(Continued from page 38)

treating operation,—for which the heat treater erroneously gets the blame!

Design Details

When designing for high tensile values, special care must be taken to avoid sharp corners, notches, reentrant angles and sudden changes of section, not only because these invite trouble in heat treatment but also, even worse, because they promote failures in service. The higher the yield strength, the less able the metal is to adapt or adjust itself to localized areas of stress concentration.

Salt Bath Quench (Martemper)

It is well known that the use of certain molten salts, (sodium and potassium nitrate and nitrite in eutectic proportion) as a quenching medium, reduces the shock of quenching and therefore tends to minimize deformation problems. For thin sections, salt quenching (martempering) may produce excellent properties. The salt bath may be used at temperatures such as 400°-600°F or even higher. There is, of course, no danger of flash fire as with oils.

Therefore, a number of heat treating plants, both in-plant and commercial, have installed molten salt quenching baths for rockets, and some engineers have even demanded martempering in the belief that it conveys superior properties.

From many years' experience with both oil and salt bath quenching, the writer has found quenching oils, when correctly and skillfully operated, to be definitely preferable to salt baths. It has repeatedly been demonstrated, both in our own plant and in comparison with other sources, that required high tensile properties can be obtained with *less* deformation in oil than in nitrate baths.

Moreover, salt bath quenching is more sensitive to mass effect than oil; heavier sections do not fully harden. Therefore, in a rocket body including a thin walled shell, integral with a thicker nozzle or head section, hardening of the latter may be inadequate with salts, but satisfactory with oil.

The addition of water to nitrate quenching baths may lower their melting point and increase the quenching power, but this process involves problems of stability and is not always a satisfactory expedient.

Fire Hazard—Nitrates

While nitrate quenching baths do not themselves burn, they present a very serious fire hazard because of their highly oxidizing character. Disastrous fires have occurred in plants where nitrate baths have burst or leaked, allowing the hot salts to come in contact with carbonaceous matter, such as wood or oil,—the gunpowder reaction. Contact with cyanide salts, often used in heat treating plants, results in violent explosion.

The use of salt quenching baths also includes the hazard of salt entrapment in crevices of the body, although these nitrate salts, unless contaminated, are less

corrosive than the chlorides used at higher temperatures. Chemists should consider the possible effects of fuel contamination by traces of nitrates.

Hot Oil Quenching

Quenching oils can be used at elevated temperatures, some special oils as high as 600°F. Ordinary high-grade quenching oils (flash point 350°F) can be operated as high as 250°F. A range of 175° to 225°F has been shown to give excellent results, including the essential combination of maximum yield strength with minimum deformation.

Experiments with special oils at 400° to 500°F at our plant have not been encouraging, either concerning deformation control or physical properties, including mass effect; and these oils tend to deteriorate with use.

Fire Hazard—Oil

Quenching in oil, at ordinary or elevated temperatures, naturally involves fire hazard. It is necessary to prevent overheating of the entire tank by a cooling device, and to replace excessively heated surface oil by circulation. Adequate fire protection should be provided, in case of accidental overheating. Carbon dioxide in the form of bottled gas or snow, foam extinguishers and certain powders are effective.

Tempering

Several gantry furnace installations include a vertical, ordinary pit type tempering furnace mounted in the pit along with stationary quench tanks, etc. The tempering operation normally takes much longer than the quenching cycle, therefore the latter would be retarded unless there are two tempering pits. Some engineers have demanded vertical tempering, under the impression that this would contribute to better straightness and roundness. Actually, proper tempering is done in fixtures which correct some previous deformation and therefore can be performed more readily in a horizontal furnace. Tempering furnaces should always have recirculating fans or blowers for temperature uniformity. Artificial atmosphere is usually not necessary at tempering temperatures.

Cooperation Needed

In these days of enormously accelerated advances in technical fields, no individual, no matter how diligent, can hope to keep abreast of more than one chosen field or profession, and hardly that. Therefore a constructive exchange of information among specialists in various lines is essential if best results are to be accomplished in the shortest time and at lowest cost. Let the designer decide what is wanted and then let the metallurgist advise him how to get it.

Overemphasis on military secrecy in such conferences, especially on matters which are more or less in the field of specialized but basic engineering knowledge, may retard rather than promote the rocket and missile program.

Engineering progress has always depended upon the more efficient adaptation of the properties of mat-

A completely NEW line!

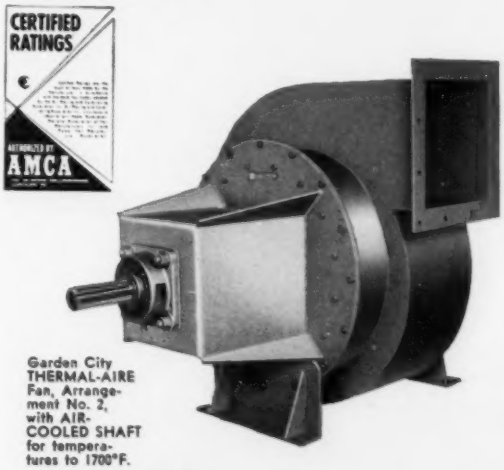
GARDEN CITY

RF

THERMAL-AIRE FANS

- **simple to install**
- **inexpensive to maintain**
- **temperatures to 1850°F.**

Garden City's new RF THERMAL-AIRE radial blade fans are durable, trouble-free, efficient. Modern, simplified in design, they are "tailored" for various temperatures to precisely meet your needs.



Garden City THERMAL-AIRE Fan, Arrangement No. 2, with AIR-COOLED SHAFT for temperatures to 1700°F.

Write Today!

Garden City Fan Company
801 North Eighth Street
Niles, Michigan

Send me fully illustrated information on application checked below:

- ☐ **THERMAL-AIRE fans for moving air or gases at elevated temperatures.**
- ☐ **Industrial fans for exhausting dust, fumes and other atmospheric contaminants.**
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MEMBER OF AIR MOVING AND CONDITIONING ASSOCIATION, INC.

GARDEN CITY FAN COMPANY
ESTABLISHED 1879

Representatives in leading cities
801 North Eighth St., Dept. T, Niles, Michigan

For further information circle No. 30

CARBURIZING
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HEATBATH CORPORATION

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or 701 North Sangamon Street, Chicago 22, Illinois

36 Years of Service to the Heat Treating and Metal Finishing Industry

For further information circle No. 31

(Continued from page 45)

erials of construction, principally metals. Rocket design today, like high temperature turbines and jet aircraft, rests most fundamentally upon the science and art of metallurgy.

One gains the impression that rocket engineers, while they have made startling progress in electronic controls and fuels, have been inclined to take too much for granted in the basic field of metallurgy. This does not refer so much to the use of special new metals and alloys which are important in particular applications, but rather to the better and more efficient use of well-known standard alloy steels already developed in the aircraft industry. More selective judgment is needed.

For example, there has been a tendency of designers to specify a certain excellent steel, 4130, for body, nozzle and head construction, and demand strength values which could better be obtained by the use of 4135, 4137, 4140, or 4340 types, especially in the thicker sections. The higher carbon, more readily hardenable alloys also lend themselves better to close deformation control. Specifications usually originate somewhere on the design board and then are passed down through contractors, prime- and sub-, and finally reach the heat treater. Perhaps the latter knows that the strength properties and deformation limits could be obtained with more assurance and margin of safety by a selection of one of the higher alloys, but he is told "Don't take exceptions. Do it the way the blueprint says". This avoidable situation has resulted in untold problems in the rocket industry.

Always associated with the question of material selection is the problem of dimensional tolerances. Rocket designers know what maximum dimensional tolerances, —for example, roundness and straightness, —may be accepted without detriment to the performance of the missile. They should then specify this only and insist on obtaining it, even though cost of production may be increased thereby.

Furnace Outlook

The two original METLAB furnaces were destroyed by a plant fire in 1937. Two new ones were erected in the present plant, the larger of which has a heating space approximately 3 ft. dia., 13½ ft. high, in which a great many small and medium sized rocket bodies have been heat treated. (See Fig. 4). Hot oil is used as a quenching medium, although salt is available. Specified close dimensional tolerances have been consistently met. (See Fig. 5).

Rocket design calls for continually larger bodies. It has so far been impossible to obtain a clear statement from rocket engineers as to the sizes—diameter and length—which will need to be accommodated in the foreseeable future. Designs have been prepared for a new furnace, embodying technical advances over any now existing, which will be built when adequate information as to size and demand becomes available.

Facility Survey

A few years ago there were hardly half a dozen furnaces in existence suitable for treating rocket bodies. New ones have been built at a rapid rate, each one being larger than its predecessor. These furnaces and accessory equipment are costly, sometimes running up to millions of dollars. As there is little present commercial application outside of the rocket industry, the cost ultimately reverts to the Defense Program and is met by the taxpayer.

In the hope of discouraging needless duplication of equipment and assisting fabricators to find available sources of heat treating service, *Metal Treating* magazine undertook to make a survey showing sizes, locations and other pertinent data. This list, based on the best information available, with illustrations, was published in the issue of September-October, 1959. Nineteen installations were listed. Seven are in the plants of commercial heat treaters, the remainder are owned by rocket fabricators or by the Government. Some ten additional ones are planned. Some few others unknown to the editors are undoubtedly in existence. Economy suggests the efficient use of these furnaces to somewhere near capacity before expending additional large sums for duplicate equipment. The potential output of each furnace in bodies per year is large—roughly 3 hrs. per body quenched, or 40 per week on a 3-shift basis—say 2,000 per year per furnace. In the 20-odd rocket furnaces of various sizes and types existing today, 40,000 bodies a year of all sizes could presumably be handled!

Distance is no real handicap as the expense of transportation between fabricating plant and competent heat treater is an infinitesimal fraction of the final cost of the rocket. Heat treating is one of the most critical operations, and it will make or mar the ultimate success of the unit.

It should be noted that the heat treating art, especially in the ultra-difficult field of rocket bodies, requires more than a set of furnaces. Unless there is a skilled organization in charge, with experience in specialized heat treating and adequate metallurgical knowledge, such equipment may be as ineffective and potentially dangerous as a kit of surgeon's tools in the hands of an amateur. Equipment may be duplicated more readily than the brains required to operate it. • • •

What Would YOU Do?

(Continued from page 18)

THE AWARD: The arbitrator said that the mere fact of the outside contracting work, by itself, would not justify discipline, especially where the company had tolerated it in the past. On the other hand, he added, the grievant was not blameless, especially in the matter of the phone call. Under the circumstances, he reinstated the man, but without back pay. This put the employee on notice that further absenteeism caused by outside work would result in discharge.

HEAT TREATING PROTECTION WHEN HARDENING, ANNEALING, STRESS RELIEVING!

An easy to use, economical, dry powder applied to steels before heat treating can save costly hours of grinding, polishing, buffing.

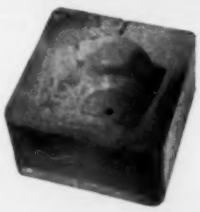
Recommended for all materials to be stress relieved, annealed and hardened at temperatures up to 1650° F., PBC is easy to use, requires no experience, just follow simple directions.

BENEFIT THESE 4 WAYS . . .

1. Prevents pitting, scale formation and decarburization.
2. Helps eliminate costly polishing, grinding and buffing operations.
3. Completely sealed from detrimental atmosphere.
4. Increases furnace capacity by eliminating time and space consuming packs.

Available in 2 pound, 5 pound, 15 pound cans and in 25 pound drums.

THIS COULD HAVE BEEN PREVENTED



RESULTS USING *PBC

*(PHOENIX-BRAND COMPOUND)

Write for literature, prices and the name of your nearest distributor today!

THE PARKER-HARTFORD CORPORATION
650 FRANKLIN AVENUE • HARTFORD 1, CONN.

For further information circle No. 32

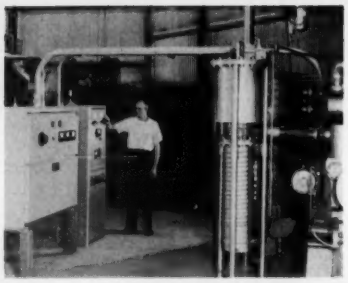
NEWS TO HEAT TREATERS

(Continued from page 43)

"PROBLEM" METALS FURNACE

The Pyromet Company, South San Francisco, Calif., has developed a high-vacuum furnace for brazing and heat treating the "problem" metals. The cylindrical work area is 24" in diameter and 24" high. The furnace can hold a vacuum of 10^{-6} mm of mercury at room temperature, and 10^{-4} mm in the 1800°-2000°F range.

The new facility makes possible greater protection from oxidation and embrittlement for such metals as titanium, beryllium, zirconium, molybdenum, tungsten, tantalum and columbium, according to the company.

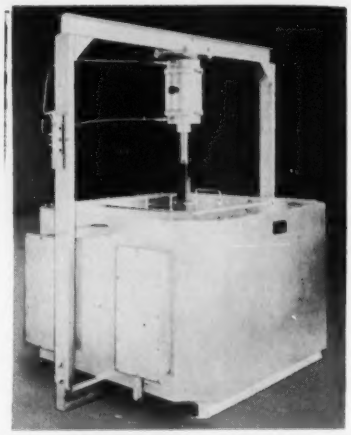


Greater strength and uniformity of brazed joints are attainable through vacuum where it is possible to process materials successfully which cannot be joined in a lesser vacuum or in atmosphere.

For further information circle No. 34

HOT LOAD TESTING FURNACE

A new electric hot load testing furnace, capable of pressure sintering at elevated temperatures up to 2750° F at pressures on the heated load up to maximum of 200 psi, has been announced by Pereny Equipment Company, Columbus, Ohio.



Infinite control of the pressure exerted on the heated load is provided by a manual control lever operating a hydraulic cylinder and ram mounted on the pressure frame.

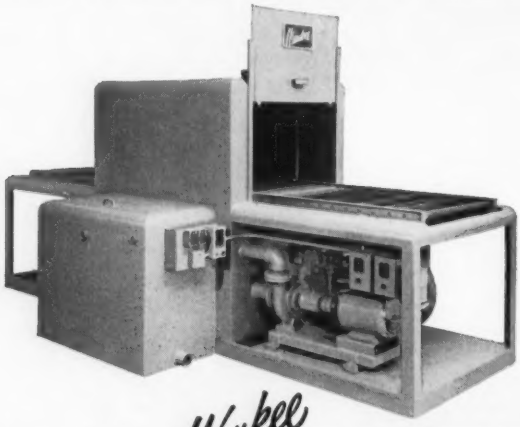
Power controls and purchaser's choice of temperature controls are mounted on a separate control panel. Power controls consist of voltage regulating transformer, fine to coarse deadfront switches (36 taps), direct reading input ammeter, and a magnetic contactor.

For further information circle No. 35

MECHANICALLY REFRIGERATED QUENCH TANK

A self-contained, refrigerated water quench tank with sufficient mechanical refrigeration capacity to lower the temperature of 50 lbs. of aluminum components or rivets from +1000° F to +34° F in 90 seconds has been developed by Webber Corporation, Indianapolis. Sufficient agitation is maintained to achieve zero stratification throughout the sweet water bath. A safety device prevents freezing.

The unit has an air lift, top open-



There's a standard Waukee® WASHER
TO MATCH YOUR CARBONITRIDER OR CARBURIZER!

Whatever the size of your carbonitrider or carburizer, the new Waukee Washer has a standard size to match it. Size range: 24 x 36 x 18 — 24 x 48 x 24 — 30 x 48 x 24 — 36 x 48 x 24.

COMPLETE — NO "EXTRAS" — Waukee parts washers come to you complete, ready to locate, connect to utilities, and begin operation. No "extras" to buy and install. Pumps, burners, controls are designed as integral parts of the Waukee Washer. You use your present furnace work-baskets, too.

FLEXIBILITY — You gain in flexibility with Waukee Washers. Standard units are available in "in-and-out" feed or straight-through, conveyor type, and in one, two, or three stages with rinse and dry. High-efficiency with gas, electricity, or steam.

THOROUGH CLEANING — The smallest Waukee Washer sprays a minimum of *one ton of hot detergent solution through the load each minute.* Solution penetrates work basket from top and bottom, washes away oil and foreign matter from the densest charge. Bull's-eye timer cycles the load for complete washing without guesswork or waste of time.

Complete data in Bulletin 1201 — write for it today.

Waukee-washed parts are free of cutting and quenching oils, mean clean furnace atmospheres, therefore predictable case depths and cleaner, brighter work.

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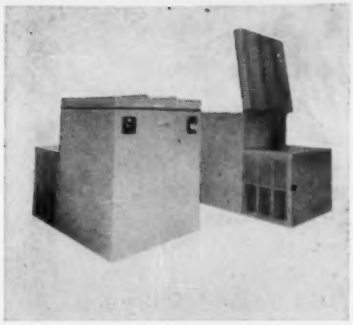
MAKERS OF WAUKEE GAS FLO-METERS • MIXORS • COMPRESSORS



ing lid. Inside tank dimensions are 37" diameter x 57" high. Outside cabinet dimensions require 48" x 48" floor space.

For further information circle No. 36

NEW HEAT TREATING PLANT

Examining performance of a new carbon restoration furnace at Industrial Metal Treating Corporation, Charlotte, North Carolina, are, left to right, President William R. DeVita, Vice President Lester E. Chaundy, Jr., and Shop Foreman Bennet L. Gupton, Jr. The new company will provide commercial

heat treating facilities for carbon restoration, carbonitriding, carburizing, bright hardening of steel, annealing, etc., as a service to the metalworking industry of the Southeast. This Leeds and Northrup furnace is of the very latest design.

For further information circle No. 37

NEW METALLOGRAPH

The availability of a new compact Meflab metallograph which meets all standard requirements was announced by the American representative for Reichert, W. J. Hacker & Co., West Caldwell, N. J. While this instrument was particularly designed for the laboratory operating on a restricted budget, its versatility is practically unlimited. Features

(Continued on page 51)

For almost every hardness testing requirement

There's a Wilson "Rockwell" instrument to do the job

Wilson "Rockwell" Hardness Testers can help make your products better, stronger, longer lasting. They give reliable results on the production line, in laboratories, in tool rooms, and in inspection departments. They're as easy to use as a center punch, as durable as a machine tool, as sensitive and accurate as a precision balance. That's why Wilson "Rockwell" is recognized as the world's standard of hardness testing accuracy.

Wilson "Brale" Diamond Penetrators give Perfect Readings

A perfect diamond penetrator is essential to accurate testing. Only flawless diamonds are used with Wilson "Brale" penetrators. Each diamond is cut to an exact shape. Microscopic inspection and a comparator check of each diamond—one by one—assure you of accurate hardness testing every time.

Write for Catalog RT-58. It gives complete details on the full line of Wilson hardness testing equipment.

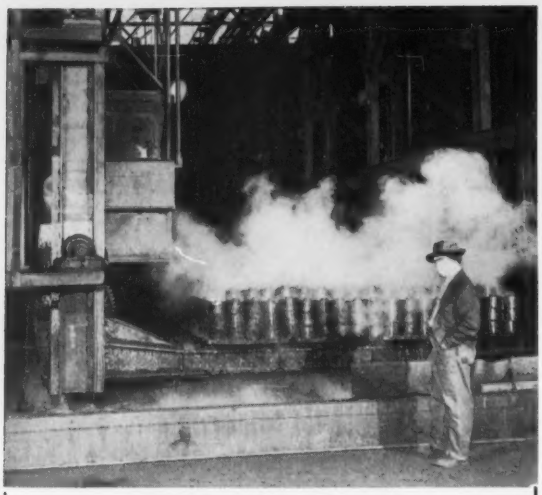
TWINTESTER
combines functions of "Rockwell" and "Rockwell" Superficial Testers
"ROCKWELL" HARDNESS TESTER
for most hardness testing functions
"ROCKWELL" SUPERFICIAL TESTER
for extremely shallow indentations
TUKON
for precision micro and macro testing
AUTOMATIC—semi and fully automatic models for automatically classifying tested pieces at rates to 1,000 pieces per hour

WILSON "ROCKWELL" HARDNESS TESTERS

ACCO

Wilson Mechanical Instrument Division
American Chain & Cable Company, Inc.
230-R Park Avenue, New York 17, New York

For further information circle No. 38



Hannite Quenching Bath

SAFE — No fire hazard
SAFE — Non-toxic
CONTROLLED quenching rates

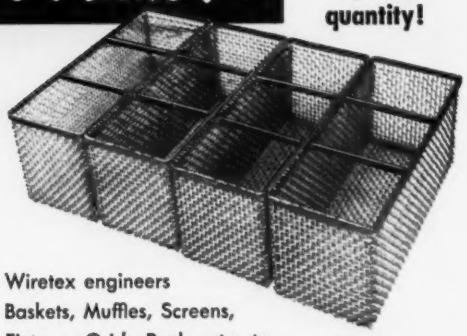
Tank Quenching, Induction Hardening,
Flame Hardening
Iron — Steel — Castings

J. HANNAN COMPANY — 12727 Buckeye Rd.
Cleveland, Ohio

For further information circle No. 39

Custom Made!

all styles, metals, weaves... any size, quantity!



Wiretex engineers Baskets, Muffles, Screens, Fixtures, Grids, Racks, etc., to insure easier, safer, loading and unloading; greater space saving; better draining and cleaning.

Call Wiretex

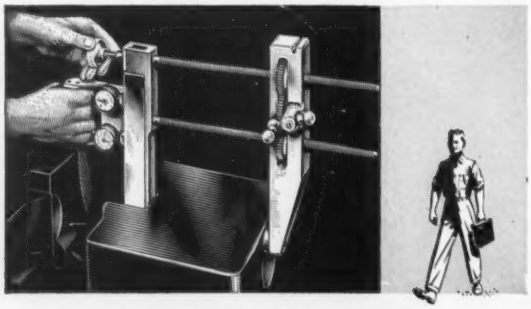
for all your heat treating requirements to resist acid, heat, abrasion or exposure.

Wiretex mfg. co.

16 Mason St. Bridgeport 5, Conn.

Specialists in Processing Carriers Since 1932.

For further information circle No. 40



Accurate Rockwell readings with PORTABLE hardness tester

Perfect for on-the-job production testing of both parts and stock materials, because it weighs just 3 lbs. 6 oz., gives accurate readings at any angle. Requires no set-up time, eliminates need for carrying large pieces to test bench or cutting test samples. Uses standard indentors and loads so no scale conversions are necessary. Rockwell scales A, B, C, D, E, F, G, H and K available as standard.

FOR A DEMONSTRATION... WRITE DEPT. MT-1159

Riehle® TESTING MACHINES

A DIVISION OF

American Machine and Metals, Inc.

EAST MOLINE, ILLINOIS

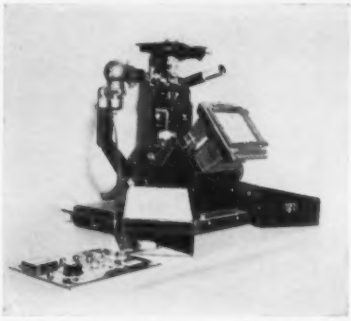
For further information circle No. 41

"SORRY, MAM, OUR 'NORMALIZING' PROCESS JUST APPLIES TO METAL TREATMENT."

NEWS TO HEAT TREATERS

(Continued from page 49)

include a built-in camera with a 4" x 5" projection screen for ready adaptation of all standard Graflok accessories and 4" x 5" Polaroid Land Camera Back. The extensible bellows camera produces images and photomicrographs of all magnifications within the range of 32x to 2200x.

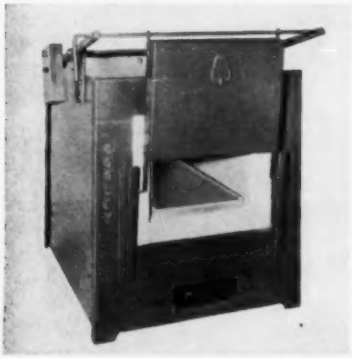


The universal opaque illuminator facilitates bright, darkfield and oblique illumination. A wide assortment of objectives and eyepieces is offered. Optional features include components for micro-hardness and surface finish testing, grain-size measuring, polarization and phase contrast metallography.

For further information circle No. 42

NEW HEAT TREATING FURNACES

Cooley Electric Manufacturing Corporation, Indianapolis, has two new electric heat treating furnaces designed for quantity production and with a temperature range of from



300°F to 2000°F. Chamber dimensions are 10" x 7" x 18" and 8" x 6" x 14". According to the manufacturer, the new furnaces feature multi-slab type of insulation, with heavy sheet steel body.

For further information circle No. 43

WATER DETECTION DEVICE

As a means of promoting safer quenching practices, an automatic water monitoring device known as the Ipsen Water Sentinel is announced by Ipsen Industries, Inc., Rockford, Illinois. It is designed for the detection of water in an enclosed type of oil quenching tank.

The continuously monitoring detector, consists of a detecting probe immersed in the oil, and sealed in the tank. The heart of the "Sentinel" is a replaceable resistor sensitive to water, which changes its electrical resistance in the order of 5:1 when subjected to emulsion-moisture in excess of 0.1%.

For further information circle No. 44

William A. Stumpf

It is with deep regret that we announce the passing of Mr. William A. Stumpf, President of The Stanley P. Rockwell Co., Hartford, Connecticut on November 11, 1959.

FURNACE COMPONENTS

8—Industrial Gas Fans—Suitable 1400° Stainless Liners & Runners 20000-35000CFM H.D. Ball Bearing ——— @ $600.00

4—McKee Pressure Blowers—2250 CFM @16 oz. 15 HP TEFC Motors @ $400.00

3—North American Pressure Blowers 2600 CFM@12 oz. 15 HP Motors @ $300.00

3—Quench Oil Coolers—39" x 18' 196-2" flues ——— Ea. $1500.00

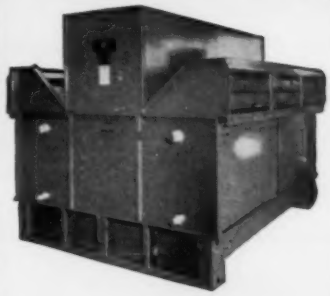
Speed Reducers — Motors
Control Equipment

HARRIS MACHINERY COMPANY
501 30th Avenue S.E., Mpls., Minn.
FE 1-1829

ALL
THE BEST
HEAT RESISTING ALLOYS
FROM STOCK

Stock List and Literature Available

ROLLED ALLOYS, INC.
Heat and Corrosion Resistant Alloy Specialists
5309 CONCORD AVE. DETROIT 11, MICH.
330 WILLIAM ST. SOUTH RIVER, N. J.



NIAGARA SECTIONAL *Aero* HEAT EXCHANGER gives close temperature control, saves you LABOR, Power, Water

- **Because the new design improves the heat transfer to the out-door air by evaporation.**
- **Because new features keep your equipment working for long life with "new plant" efficiency . . . always full capacity.**
- **Because you save 95% of cooling water cost.**

You get faster, more accurate cooling of industrial fluids to specified temperatures.

You improve your quality of production by removing heat at the rate of input.

You save labor in upkeep. With full access to all interior parts and piping you see everything in easy inspections. You head off dirt accumulation and corrosion. Casing panels are removable without moving the coils. The coils can be cleaned from both sides.

First cost is low; freight is low because of the lowest space/weight ratio; you save much labor in erection. Capacity range is 7,000,000 to 18,000,000 Btu/hr. No other heat exchange method gives you so much saving in money and convenience.

Write for Niagara Bulletin No. 132

NIAGARA BLOWER COMPANY
Dept. MG-12, 405 Lexington Ave.
NEW YORK 17, N Y.

District Engineers in Principal Cities of U. S. and Canada

For further information circle No. 45

MANUFACTURERS' LITERATURE

For your copy circle the number on the Readers' Service Card

CONVERSION CHART

A Reference Table for engineers and other executives in wall chart form has been published by Precision Equipment Co., Chicago, Ill. Included are common conversions, as inches to centimeters or watts to hp. as well as many conversions difficult to locate in reference manuals. (Some such examples are atmospheres to Kgs/sq. cm, cm/sec to miles/hr, cu. ft. to liters, microns to meters, quintal to lbs., etc., etc.)

For further information circle No. 45

DRYING EQUIPMENT BULLETIN

Gas Atmospheres, Inc., Cleveland, Ohio, announces the release of a new bulletin describing drying equipment for removal of moisture from low pressure gas or air streams. Fully automatic refrigeration and solid adsorbent dryers are featured; they may be used independently or in combination, depending on the end dewpoint required for gas or air streams. The bulletin also contains curves showing percent of moisture by volume at various temperatures and dewpoint related to moisture content per 1000 cubic feet of gas or air.

For further information circle No. 48

DESCALING MACHINES BULLETIN

Pangborn Corporation, Hagerstown, Md., has announced the publication of a new bulletin describing the complete line of Rotoblast descaling machines.

Photos, diagrams, cut-aways and sketches show details and operating features of the Rotoblast wheels which provide the cleaning force of the mechanical descaling equipment. Various cabinet designs and material handling features appropriate to the type of work being descaled are described. The bulletin covers 4-wheel and 8-wheel machines for descaling sheets, coils and plates—special machines for descaling rods, bars and wire—marginal descaling for pipe skelp—structural descaling equipment for angles, channels, H-bars and I-beams—and special installations for descaling billets and slabs.

For further information circle No. 49

IPSEN BULLETIN

The most recent product bulletin describes Ipsen equipment designed for bright carbonitriding, bright neutral hardening, marquenching, normalizing, and annealing.

The bulletin includes the latest developments of the Ipsen straight-through furnace with features designed to improve production quality, and at the same time bring you lower operating costs.

For further information circle No. 50

COMBUSTION SAFEGUARD

Protection Controls, Inc., Chicago, Ill., has published a 4-page bulletin describing its Protectofier Combustion Safeguard Control for heating and heat treating applications. The units provide continuous protection against fires or explosions from build-up of combustible fuel mixtures in either single or multi-burner installations.

Completely new developments described include compact plug-in

MORE HEAT TREATING VOLUME
with BASIC "BUZZER PACKAGE"
NO BLOWER OR OTHER POWER NEEDED
... just connect to gas supply
HIGH-SPEED FURNACE
AUTOMATIC TEMPERATURE CONTROL
GAS ATMOSPHERE FURNACE
ATMOSPHERIC POT FURNACE
LARGE OVEN FURNACE
RINSE OR QUENCH TANK
OVEN FURNACE
TEMPERING FURNACE
"BUZZER" modern gas-fired heat treating and melting units give you the most dependable, economical and productive system for turning out quality jobs at low productions costs. When power is off—"BUZZER" stays on the job! Standard and special furnaces, large or small, available to equip your shop to exact requirements.
COMPLETE LINE OF BUZZER REG. U.S. PAT. OFFICE BURNERS FOR CLEANING, RINSING, PICKLING AND SUNDRY HEAT OPERATIONS
WRITE TODAY FOR NEW "BUZZER" CATALOG
CHARLES A. HONES, INC.
145 S. GRAND AVENUE, BALDWIN, L.I., N.Y. • BAldwin 3-1110
HEAT TREATING EQUIPMENT SPECIALISTS SINCE 1911

Flame-Pak flame detector units containing entire electronic circuit, and a Telefier Combustion Safeguard Indicator System which reduces downtime by providing numerical display of faulty burner position if flame failure occurs.

For further information circle No. 51

GUIDE TO FERROUS METALLURGY

The Tempil° "Basic Guide to Ferrous Metallurgy" in a 4-color, 8½" x 11" version is now available from Tempil Corp., New York. This is a convenient size for engineers' data books.

The principal characteristics of steels (with carbon content ranging to 0.9%) are represented across the temperature range to 2900°F. The important working zones, including preheating for welding, stress relieving, normalizing, annealing, carburizing and forging are shown. At the right of the chart, 24 common metallurgical terms are defined and explained. A diagram symbolizing the change in grain size with temperature appears at the left.

The reverse side of the chart serves as a catalog page, illustrating Tempilstiks°, Tempilaq° and Tempil° Pellets, and listing the available temperature ratings for each of these temperature indicating materials.

For further information circle No. 52

TEMPERATURE CONTROL

"Temperature Control of Heat Treating Furnaces" is the title of a 24-page bulletin which is a reprint of a series of articles on this subject.

The illustrated publication published by General Electric, contains information about thermocouples, control instruments, control elements, control systems and special systems. Author discusses all phases of temperature control listing definitions, basic types, and how to select the proper item.

For further information circle No. 53

DATA FOR METALLURGISTS

The Timken Roller Bearing Company, Steel and Tube Division, has published a newly-revised edition of their 76-page, pocket-size booklet entitled *Practical Data for Metallurgists.*

This booklet contains the very latest metallurgical information concerning standard steels, their chemical compositions, and hardenabilities.

For further information circle No. 54

STEEL ANALYSES

A convenient pocket-size booklet, this twenty-page guide lists the compositions of forty stainless steels, 184 alloy steels and 105 carbon steels most often used in industry.

For further information circle No. 55

ULTRASONICS AND HEAT TREATING

The following two translations of articles published in foreign trade journals are available in English:

Effect of Ultrasound on Various Changes in Steel at High Temperatures. S. Tanaka, T. Yoshida, and K. Takagi. TETSU TO HAGANE, vol. 37 1951, #10, pp. 25-30; 16 figures, 4 tables, 1500 words. (Investigation of effect of ultrasound upon changes in structure of steel being heat treated. Experimental apparatus (Figs. 1 and 2) and procedure (Figs. 3 and 4). Data on effect of ultrasound and transformations in dilatometric analysis, structures obtained upon quenching; grain growth and grain-size distribution; scaling; diffusion of carbon; and structural changes in general.) Price $4.90. No. 4158

Aging of Creep-resisting Nickel-base Alloy EI 437B Accelerated by Ultrasonic Vibrations. V. S. Ermakov and E. A. Al'ftan. METALLOVEDENIE I OBRABOTKA METALLOV, July 1958, #7, pp. 22-27; 4 figures, 2400 words. (Literature data on effect of ultrasonic energy on rate of heat treating of various nonferrous and ferrous alloys. Apparatus selected by authors for their study: circuit diagram (Fig. 1) and design features. Experimental procedure. Equation for calculating the stress and stress amplitude. Heat treating (aging) etc. of 20% Cr, 1.4 Ti, rest Ni alloy . . . Enormous time savings by even low-power u.s. vibrations . . .) $4.90. No. 4278.

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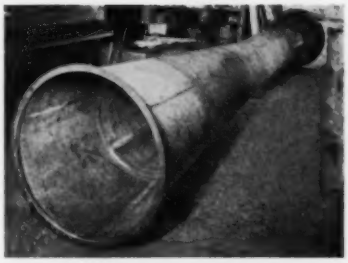

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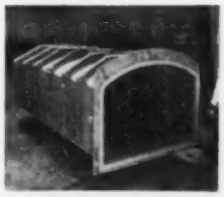

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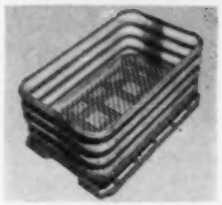

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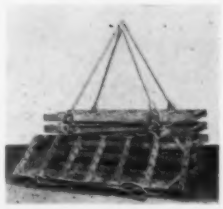

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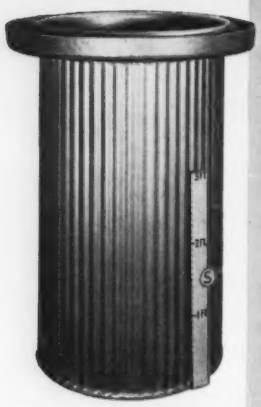

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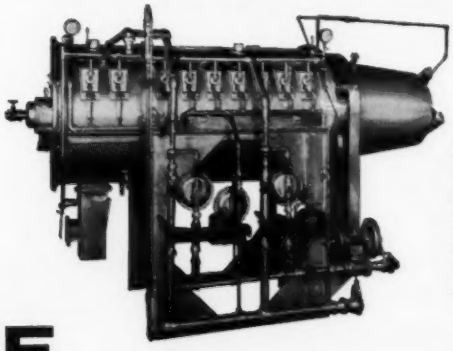

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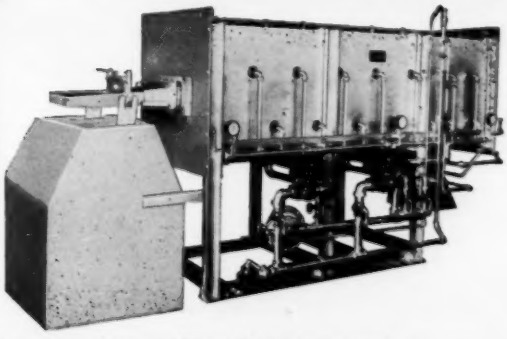

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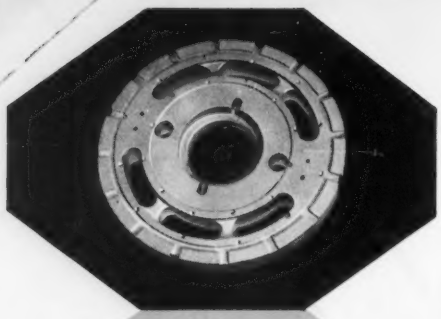

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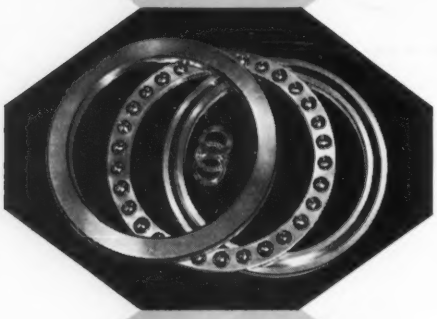

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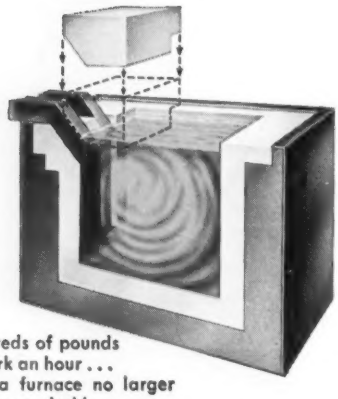

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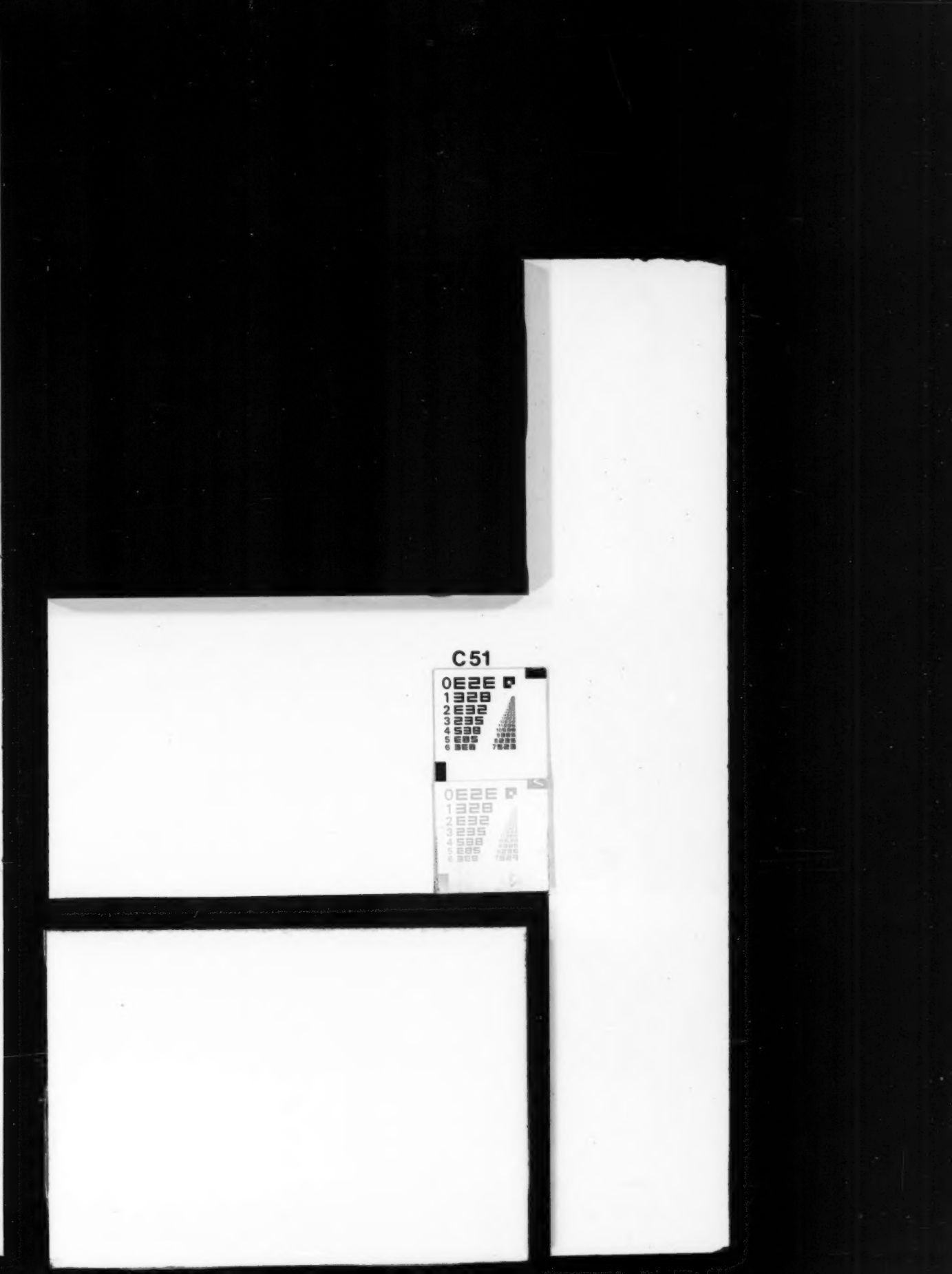
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